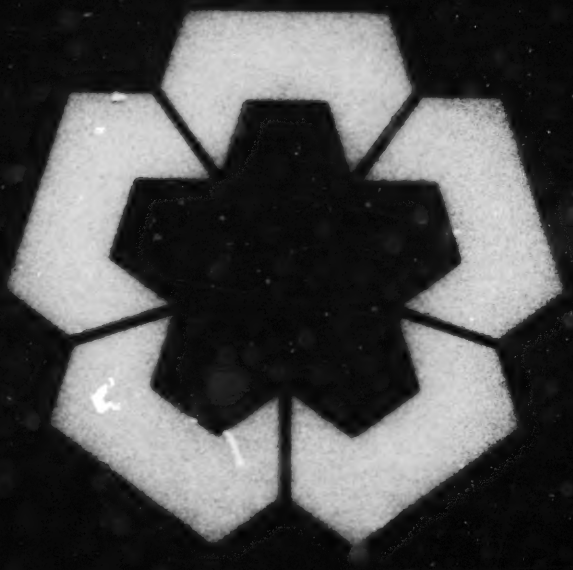

Atmospheric Biosphere Interface Probability Analysis and an Experimental Design for Studies of Air Pollution Impacts on Plant Response

84- 3325 /

The logo represents the interdisciplinary and holistic nature of the Division's environmental research programs. Each of the five sections of the symbol represent comprehensive programs on air, water, land, humans, and their constant interaction. The sections converge to form a cohesive chain, characteristic of an effective research organization. This cohesive bonding makes the sections blossom into the environment in the form of a flower — an Albertan wild rose.

# ATMOSPHERE-BIOSPHERE INTERFACE:

# PROBABILITY ANALYSIS AND AN EXPERIMENTAL DESIGN

# FOR STUDIES OF AIR POLLUTANT-INDUCED PLANT RESPONSE

RESEARCH MANAGEMENT DIVISION
Alberta Environment

For information on reports published by the Research Management Division, contact:

Research Management Division
14th Floor, Standard Life Centre
10405 Jasper Avenue
Edmonton, Alberta
T5J 3N4

(403) 427-3946

This report may be cited as:

Nosal, M. 1983. Atmosphere-biosphere interface: probability analysis and an experimental design for studies of air pollutant-induced plant response. Prep. for Alberta Environment, Research Management Division by Statistical Research Laboratory, University of Calgary. Edmonton, Alberta. RMD Report 83/25. 98 pp.

# ATMOSPHERE-BIOSPHERE INTERFACE:

# PROBABILITY ANALYSIS AND AN EXPERIMENTAL DESIGN

# FOR STUDIES OF AIR POLLUTANT-INDUCED PLANT RESPONSE

by

DR. M. NOSAL

Statistical Research Laboratory
University of Calgary

and

Statscon, Statistical Consulting Co.

for

RESEARCH MANAGEMENT DIVISION
Alberta Environment

RMD Report 83/25

June 1983

This report is made available as a public service. The Alberta Department of Environment neither approves nor disagrees with the conclusions expressed herein, which are the responsibility of the authors.

## TABLE OF CONTENTS


| | | Page |
|---|---|---|
| LIST OF TABLES | | vi |
| LIST OF FIGURES | | viii |
| ABSTRACT | | ix |
| ACKNOWLEDGEMENTS | | x |
| 1. | INTRODUCTION | 1 |
| 2. | CRITICAL ASSESSMENT OF THE EXISTING MODELS FOR AIR POLLUTANT-INDUCED PLANT RESPONSE | 3 |
| 3. | ANALYTICAL PROBABILISTIC MODEL | 16 |
| 3.1 | Data Description | 16 |
| 3.2 | Pollutant Dose Quantification | 18 |
| 3.3 | Model Derivations | 19 |
| 3.4 | Numerical Analysis of Pollutant Exposure and Plant Response | 20 |
| 4. | RECOMMENDATIONS FOR EXPERIMENTAL DESIGN AND PREDICTION ANALYSIS OF AIR POLLUTANT-INDUCED PLANT RESPONSE | 24 |
| 5. | REFERENCES | 26 |
| 6. | APPENDICES | 28 |
| 6.1 | Regression Analysis of Data on Plant Response to Air Quality | 28 |
| 6.2 | Plant Response Data | 44 |
| 6.3 | Summary of Fumigation Episodes | 52 |
| 6.4 | Time Series of Pollutant Episodes | 89 |

## LIST OF TABLES


| | | Page |
|---|---|---|
| 1. | Summary of Accuracy of Numerical Regression Model | 22 |
| 2. | Regression Analysis of Plant Response to Dispensed $SO_2$ | 29 |
| 3. | Regression Analysis of Plant Response to Dispensed $O_3$ | 34 |
| 4. | Regression Analysis of Plant Response to Residual Ambient, Unfiltered, and Filtered Air | 39 |
| 5. | Summary of Plant Response Data | 45 |
| 6. | Plant Response Data | 46 |
| 7. | Chamber A5-dispensed $SO_2$ data | 53 |
| 8. | Chamber A6-dispensed $SO_2$ data | 54 |
| 9. | Chamber C2-dispensed $SO_2$ data | 55 |
| 10. | Chamber C3-dispensed $SO_2$ data | 56 |
| 11. | Chamber D6-dispensed $SO_2$ data | 57 |
| 12. | Chamber E1-dispensed $SO_2$ data | 58 |
| 13. | Chamber B1-dispensed $O_3$ data | 59 |
| 14. | Chamber C4-dispensed $O_3$ data | 61 |
| 15. | Chamber D3-dispensed $O_3$ data | 63 |
| 16. | Chamber D4-dispensed $O_3$ data | 65 |
| 17. | Chamber E3-dispensed $O_3$ data | 67 |
| 18. | Chamber E5-dispensed $O_3$ data | 69 |
| 19. | Chamber A1 residual treatment $SO_2$ data | 71 |
| 20. | Chamber A1 residual treatment $O_3$ data | 72 |
| 21. | Chamber A3 residual treatment $SO_2$ data | 74 |
| 22. | Chamber A3 residual treatment $O_3$ data | 75 |

## LIST OF TABLES (CONCLUDED)


| | | Page |
|---|---|---|
| 23. | Chamber B2 residual treatment $SO_2$ data . . . . . | 77 |
| 24. | Chamber B2 residual treatment $O_3$ data . . . . . | 78 |
| 25. | Chamber B3 residual treatment $SO_2$ data . . . . . | 80 |
| 26. | Chamber B3 residual treatment $O_3$ data . . . . . | 81 |
| 27. | Chamber D1 residual treatment $SO_2$ data . . . . . | 83 |
| 28. | Chamber D1 residual treatment $O_3$ data . . . . . | 84 |
| 29. | Chamber D5 residual treatment $SO_2$ data . . . . . | 86 |
| 30. | Chamber D5 residual treatment $O_3$ data . . . . . | 87 |

## LIST OF FIGURES


| | | Page |
|---|---|---|
| 1. | Chamber A5-dispensed $SO_2$ | 90 |
| 2. | Chamber A6-dispensed $SO_2$ | 91 |
| 3. | Chamber C2-dispensed $SO_2$ | 92 |
| 4. | Chamber C3-dispensed $SO_2$ | 93 |
| 5. | Chamber D6-dispensed $SO_2$ | 94 |
| 6. | Chamber E1-dispensed $SO_2$ | 95 |
| 7. | Chamber D3-dispensed $O_3$ | 96 |
| 8. | Chamber D4-dispensed $O_3$ | 97 |
| 9. | Chamber E3-dispensed $O_3$ | 98 |

## ABSTRACT

This report presents a critical assessment of the state of knowledge about the numerical definition of air pollutant dose as it relates to vegetation response. The first part of the report is a literature survey of the majority of recent publications in this area, including reports of the National Crop Loss Assessment Network (NCLAN). A numerical probabilistic model is then developed and its statistical goodness-of-fit to air pollutant exposure-soybean response data is analysed in detail. These data were supplied by Dr. Sagar V. Krupa of the Department of Plant Pathology, University of Minnesota. While the emphasis in this report is on the pollutant-response model development, no effort was made to apply the model to actual crop loss assessment in Minnesota because of the paucity of relevant data. Finally, the findings are applied to an experimental design for integrating air quality data to vegetation response and predictions in Alberta.

## ACKNOWLEDGEMENTS

This project was carried out under the auspices and in close collaboration with the Research Management Division, Alberta Environment, which also provided the necessary funding for the work.

I am particularly indebted to Dr. Sagar V. Krupa for his very fruitful discussions and also for his kind permission to use his highly valuable data on soybean response to various pollutants. I am also very thankful to Dr. Allan Legge for his helpful assistance in clarifying basic concepts. The data were computerised and computer programs were written by Paul Kubicek with assistance from Pete Graw. My thanks are also given to Tae Nosal for her help with the final report preparation.

## 1. INTRODUCTION

Growing concerns regarding the impacts of air pollutants on the environment have led to increased efforts to collect extensive data on air quality and vegetation response. Comparatively little work has been done to date on linking these two data sets and investigating cause-effect or dose-response relationships under field conditions.

This report summarizes the state of knowledge of the numerical definition of air pollutant dose as it relates to vegetation effects. Only selected recent publications (1976 to 1983) have been included. The results described in many older publications have been either assimilated or expanded and further developed in recent papers and, therefore, were omitted from this survey. The main criterion in the selection of the information included in this report was the relevancy to mathematical modelling of the pollutant dose- vegetation response relationship.

Many empirical models have been developed for the description of pollutant dose-plant response relationships under field conditions. However, these models have a number of limitations:

1. They have been developed from data based on steady state artificial pollutant fumigations.
2. They are linear in their pattern and thus oversimplify the inherent non-linear relationship between the pollutant dose and plant response under field conditions.

The data supplied for this project by Dr. S.V. Krupa from the Department of Plant Pathology, University of Minnesota, on soybean exposure to $SO_2$ and $O_3$ are not hindered by the first problem. Therefore, the present study emphasises the numerical aspects of pollutant dose quantification as it applies to both chronic exposures and episodic regimes of ambient pollutant concentration. Because of the limited data, no effort was directed in this study to crop loss

assessment as it relates to Minnesota. The basic parameters introduced here for the development of the model are:

1. integral of the pollutant concentration and the duration of individual exposures as observed over the entire growth season, and their cumulative function;
2. the peak concentration of the individual episodes; and
3. the total number of episodes (above a certain threshold) observed during the entire growth season.

These dose parameters have been calculated for the field experimental data on soybean exposure to $SO_2$ and $O_3$, supplied by the scientists at the University of Minnesota. The air quality data were related to various plant response parameters such as the number of pods per plant, number of seeds per plant, seed weight per plant, and thousand seed weight.

The main problem was to derive a proper numerical model that can satisfactorily explain the cause-effect relationship. Linear models were inadequate because of the intrinsic non-linearity of the chronic exposure-plant response phenomenon. After an extensive number of trials, a mixed multivariate polynomial-Fourier regression model was satisfactorily applied. The goodness-of-fit was very high, with the coefficient of determination $R^2$ always ranging over 85% and in a majority of cases over 96%.

The last section of this report provides recommendations for experimental design and prediction analysis for integrating air quality data to vegetation response in Alberta.

## 2. CRITICAL ASSESSMENT OF THE EXISTING MODELS FOR AIR POLLUTANT-INDUCED PLANT RESPONSE

Experimental methods investigating pollution effects and prediction of plant yield response often use artificial fumigations applied within specified field plots or chambers. One of the main problems encountered in such experimental designs is the requirement that the statistical parameters of the artificial fumigation process be very similar to those encountered in ambient air in the given geographic area. One of the better models for this purpose is the pollution time series model suggested by Male (1982:2248).

In Male's model it is assumed that the distribution of concentrations of a given pollutant is lognormal; that is, it has the following distribution function:

$$LN(c;\ m,\sigma) = \int_0^c \frac{1}{\sigma y\sqrt{2}} \exp\left[-\frac{1}{2}\left[(\ln y - \ln m)/\sigma\right]^2\right] dy$$

Furthermore, it is assumed that the pollution concentration C(t) is stationary of the form

$$C(t) = m\left|\frac{C(t-1)}{m}\right|^{\lambda} Z(t)$$

where Z(t) represents independent, lognormal random variables with median 1 and shape parameter $\sigma\sqrt{1-\lambda^2}$; that is:

$$Z(t) \sim LN(1, \sigma\sqrt{1-\lambda^2})$$

The parameter $\lambda$ determines the degree of dependence in the process. The corresponding autocorrelation function is

$$\rho(h) = \frac{\exp(\sigma^2\lambda^h) - 1}{\exp(\sigma^2) - 1},\quad h > 0,\ 0 < \lambda < 1$$

where h is the lag.

This model is used for defining the fumigation schedules in experimental exposure chambers with one-hour resolution. Furthermore, the paper describes how to generate an n-hours long time series which has a specified sample median $\hat{m}$ and specified sample parameters $\hat{\sigma}$ and $\hat{\lambda}$.

There are several points in this paper which require closer scrutiny:

1. The assumption concerning the lognormal distribution of the pollutant concentrations is not valid. Under field conditions there are frequent occurrences of zero concentrations (below the detection limit of the measurement methodology). If one were to use "zero," then the logarithm of many concentrations is undefined. Hence, zero concentrations must be omitted even though they represent a vast majority of observations. The assumption of "log-normality" is, therefore, undesirable and better models are needed (e.g., Pearson family of distributions).
2. Even though the title of the paper is "An experimental method for predicting plant yield response to pollution time series," the author does not attempt to quantitatively analyse the plant response.

A mathematical model for the investigation of $O_3$- and $SO_2$-induced leaf injury was developed by Larsen, Heck, Heagle, and others (Larsen and Heck 1976:327; Heagle and Heck 1980:296; Heck, Larsen, and Heagle 1980:32; Larsen, Heagle, and Heck 1983:200). Again, this model is based on the assumption that air quality data appear to be lognormally distributed. For a particular exposure duration, the pollutant concentration expected to injure a certain percentage of leaf surface was expressed by the following equation:

$$c = m_g s_g^z t^n$$

where

$m_g$ = geometric mean pollutant concentration for one hour
$s_g$ = standard geometric deviation
$n$ = slope of lines with the same percent leaf injury
$c$ = pollutant concentration
$t$ = time
$z$ = the number of standard deviations that an observed percent leaf injury is away from the median.

After deriving logarithms, a stepwise multiple linear regression was used to calculate the parameters $m_g$, $s_g$, and n for least square best fit of the above equation to the experimental data. This model was used to analyse leaf injury after exposure to $O_3$ and $SO_2$, and also $O_3$ plus $SO_2$.

Unfortunately, the above-quoted papers by Heck and others contain many unclear points, some of which are summarised below:

1. The mathematical model for the leaf injury is empirical and is not analytically derived. It is assumed that the model fits the field situation. However, the data provided in Figures 1 and 2 of Larsen, Heagle, and Heck (1983) do not support the assumption.
2. The model is based on the assumption that "air quality data" and any "such data appear to be lognormally distributed." It is now generally accepted that this assumption is not valid, as discussed in greater detail later in this report.
3. The last paper in the series (Larsen, Heagle, and Heck 1983) attempts to deal with chronic exposures, in addition to the acute exposures, but falls short of this aim. The attempt to relate results to National Ambient Air Quality Standards is not necessarily valid and is not supported by the evidence.
4. The authors have used overly complicated technical terminology (e.g., "the standard geometric deviation" or "geometric mean concentration, [which is by definition not a geometric mean]) along with undesirable statistical data analysis (e.g., "each equation can be expressed as a function of z" or "observed percent leaf injury is away from the median," or "the percentage of concentrations... is often transformed to a Gaussian variable"). Despite these efforts, the corresponding entities are treated as simple parameters in a simple linear regression.

5. The authors analysed two plant cultivars (Lee 68 and Dare soybeans) within one model without consideration of the apparent heterogeneity of their data.

Crop loss in the US due to air pollutants ($O_3$, $SO_2$, and $NO_2$) has been estimated to be between one and two billion dollars a year. Given this economic impact, the US Environmental Protection Agency (EPA) initiated the National Crop Loss Assessment Network (NCLAN) to evaluate the immediate and long-term economic consequences of the effects of air pollution on crop production. Results of the first few years of activity of this network are reported in Heck et al. (1982:353). The primary objectives of the NCLAN include:

1. the development of crop loss functions that can be used to determine or predict economic losses to crops due to air pollutants, especially $O_3$, $SO_2$, and $NO_2$; and
2. the advancement of the understanding of the cause and effect relationships that determine the crop response to pollutant exposure.

Because of the extensive research necessary to explain the complex response functions, it is anticipated that full results will not be available for any plant species before 1984 (i.e., after more than four years of research work).

The experimental design of the NCLAN involves the use of open-top fumigation chambers together with six different ozone treatments:

1. AA - ambient air;
2. CF - filtered air;
3. NF1 - non-filtered air with $O_3$ artificially added to resemble AA (about 0.015 ppm of $O_3$);
4. NF2 - as NF1 plus 0.03 ppm of $O_3$ artificially added for seven hours/day;
5. NF3 - as NF1 plus 0.06 ppm of $O_3$ artificially added for seven hours/day;
6. NF4 - as NF1 plus 0.09 ppm of $O_3$ artificially added for seven hours/day.

A total of five different plant receptors (kidney bean, peanut, turnip, soybean, and head lettuce) were studied at five different geographic locations throughout the US.

The following numerical models were considered for the regression between the $O_3$ concentration and crop loss:

1. Simple linear function:

$$y = b_0 + b_1 x$$

where
y = yield in g per plant
x = mean $O_3$ concentration

2. Plateau-linear model:

$$y = b_0 \qquad \text{if } x \leq \theta$$
$$y = (b_0 - b_1\theta) + b_1 x \qquad \text{if } x \geq \theta$$

3. Percent yield reduction model:

$$y = \frac{100 b_1}{a} [.025 - x]$$

A number of points in this paper deserve closer scrutiny:

1. As Figure 4 indicates, most regression scattergrams have only five to six points (corresponding to different treatments). The fitting is done using models with two (model A) or three (model B) parameters. It follows from theoretical statistics that a high $R^2$ value as reported in the paper does not necessarily reflect a high degree of fit of the model but is a logical (not empirical) consequence of a limited experimental design. Sparse data (five points) are overparameterised by a three parameter model and good fit is theoretically guaranteed regardless of reality. This is a very serious

shortcoming which is common to many studies of this type including, to a certain degree, our own project.

2. The ozone concentrations in chambers NF1 to NF4 differed only by a constant value during the whole experiment. This is contrary to the episodic nature of $O_3$ concentrations and their spatial variability under ambient conditions. Hence, the results may be theoretically interesting but their applicability to field conditions is questionable. It should be emphasised that steady state artificial fumigation experiments cannot be used to completely describe the effects of air pollutants on ecosystems. For this purpose, one has to use dynamic flux experimental designs as reported in Nystrom et al. (1982) and Pratt (1983).
3. The experimental design is very extensive (five species were tested) but not sufficiently intensive (only six treatments, of which only four--NF1 to NF4--can be expected to cause observable effects). The resulting data then yield only five to six points on the regression scattergrams, with the highly undesirable consequences described in item (1) above.
4. The linear models A to C seem to fit only because they overparameterise the sparse data. It is doubtful whether these models would fit well even if sufficient data were collected. It is unrealistic to force linear models on relationships which are, in principle, non-linear.

A rather unusual approach to modelling pollutant-crop interactions is offered by Kercher and Bingham (1982). This paper offers a mathematical model for estimating crop yield losses due to pollutants using a physiologically-based simulation approach. This effort is part of the NCLAN.

The paper is interesting from several different aspects:

1. There are eight different equations given with no clear relationship among them. Furthermore, these equations have no relation to other models used within NCLAN, as reported for example in Heck et al. (1982). There are also obvious typographical errors in these equations.
2. None of these models have been verified or even tried with actual field data. The authors state that some variables are "difficult to arrive at experimentally." Furthermore, no discussion of the possibility of a future experimental design for verification of the model is offered. Hence, the actual value of such models remains to be verified.

Many investigators adhere to the assumption that pollutant concentrations follow the lognormal distribution. This assumption has been questioned and evidence to the contrary has been offered by Berger, Melice, and Demuth (1982:2863). The authors used 24-hour averages of $SO_2$ concentrations over a two- and one-half year period in the region of Ghent in Belgium. Lognormal distribution was fitted to the data with the expected poor results. The differences between the empirical data and the lognormal curve were most pronounced at extreme values of the 95th and higher percentiles. For this reason, the authors used the two-parameter gamma distribution:

$$F(x) = \frac{1}{\beta^{\alpha}\Gamma(\alpha)} \int_0^x x^{\alpha-1} \exp\{-\frac{x}{\beta}\}dx$$

The gamma distribution provided a much better fit and the goodness-of-fit was confirmed by several tests of significance.

A mathematical index that describes ozone concentration, frequency, and duration was developed by Lefohn and Benedict (1982). The approach is based on Weibull distribution for ambient ozone data. The index considers ozone concentration, duration of exposure, and frequency of occurrence. The integrated exposure (IE) is determined by

summing the product of concentration times the total time observed above 196 $\mu gm^{-3}$:

$$IE = OE \times 56.76\ \mu gm^{-3} h\ (pphm\ h)^{-1} + 176006\ \mu gm^{-3} h$$

where

OE = oxidant exposure taken as 7 hours average

This index was correlated with crop loss in several California counties. The correlation was as high as an $R^2$ value of 0.954 and it appears that this index seems to have captured the essence of the impact of pollutant dose on crops. At the same time, the previously-described approach of Lefohn and Benedict to dose-response relationship is somewhat similar to our own project because it considers concentration, duration of exposure, and frequency of occurrence expressed in an integral form. However, it is not as powerful because it omits other parameters of concentration distributions, such as peak concentrations and numbers of episodes.

Results of an extensive experiment investigating the effect of $O_3$ and $SO_2$ on soybeans were reported by Pratt (1983) and by Nystrom et al. (1982). A computer-controlled open-top field chamber system was used. A computer also provided automatic data gathering on the following experimental treatments:

1. six open-top chambers with filtered air and $SO_2$ artificially dispensed;
2. six open-top chambers with filtered air and $O_3$ artificially dispensed; and
3. residual treatments consisting of chambers with unfiltered or filtered air and ambient field plots without chambers.

The pollutant concentrations were controlled by a microcomputer and the exposure regimes were based on normally occurring and measured pollutant concentrations and exposure durations in the study area. These factors make the data from this experiment particularly interesting because they can be directly related to real atmospheric scenarios. The dynamic flux, artificial experimental

fumigations express the episodic character of the natural variations in air quality much better than the steady state (constant) fumigations used in NCLAN experiments. Efforts were made to fit the air quality data from each chamber to standard distributions such as normal, lognormal, or gamma. However, the reported goodness-of-fit was poor and the method was discarded. It is rather unfortunate that Pratt (1983) had not tried the Pearsonian family of distributions, because by using this approach a good fit of atmospheric air quality data can often be obtained.

Attempts were made with each of the crop yield components to express the effect of the exposure using statistics describing the pollutant dose. For the model, the multivariate linear regression was applied. The dose was quantified in terms of the arithmetic and geometric mean of the pollutant concentrations, the median, and the number of peaks. The calculated fit was poor and had no predictive value.

It appears that while modelling the dose-response relationship Pratt (1983) oversimplified two factors:

1. The linear model is incapable of capturing a relationship which is non-linear in its nature. A non-linear model should have been used, even though this type of approach is much more complex to handle.
2. The dose quantification appears to be somewhat crude. Average or median concentrations have a rather poor predictive value in the case of highly episodic events having great variability. The actual size of the peaks as well as the influence of the overall "episode integral" was neglected.

Some very important and interesting theoretical observations regarding estimating air pollutant-induced ecological effects were given in Krupa and Teng (1982). These investigators summarise some general theoretical principles for modelling the stimulus-response of biological ecosystems. The ideas stated in this study are clearly formulated and

could be used as basic concepts for any study attempting a cause- effect investigation of air pollutant-induced ecological impact.

Uncertainty is a phenomenon which cannot be overestimated when modelling biological systems. The majority of biological stimulus-response relationships are stochastic in nature, and corresponding models always yield a residual "unexplained" variance. Errors in stimulus-response investigations can be threefold:

1. errors due to inappropriate experimental design;
2. errors due to inappropriate data generation and collection; and
3. errors due to inappropriate mathematical models and their application.

The authors state the following important facts about the experimental design: "It is more meaningful to create a broad range of exposure regimes than to intensively replicate a few exposure regimes. Defining a response surface demands...response surface methodology which in general emphasizes the number of treatments over number of replications." This fundamental maxim must be followed in order to collect useful data. Unfortunately, all presently-available data sets, and particularly NCLAN data, violate this rule to some degree.

The authors also emphasise the need to create artificial exposure regimes (fumigations) which are realistic and which simulate natural pollutant occurrences. This clearly implies that priority must be given to dynamic flux fumigations which are episodic in nature over the steady state fumigations which are so frequently used (e.g., by the NCLAN). Another problem deserving special attention is the quantification of the pollutant dose. The use of models based only on mean values (averages) is inappropriate because this approach is incapable of capturing the great variance of episodic pollutant concentrations. The distribution of pollutant concentrations ($SO_2$ or $O_3$) in ambient air is almost always non-symmetrical, strongly skewed, and has a very high variance as compared to the mean value (see, for example, data in Tables 7 to 30). It is a well known fact that, for such distributions, the use of the average value is much less

meaningful compared to its use for symmetrical distributions (e.g., normal distribution) and can sometimes even be misleading and wrong.

The aforementioned rules should be considered as fundamental concepts in any investigation of biological stimulus-response relationships. Any serious violation of these principles will certainly limit the validity of the corresponding findings.

Quantitative models for the economic assessment of air pollutation damage to agricultural and silvicultural crops in Minnesota are given in Benson et al. (1982:4). The study was conducted in two parts. The main objectives of the first part were to estimate yield losses due to $O_3$ and $SO_2$ for major crops in Minnesota and to model these losses. The second part of the study consisted of an economic analysis and is not of direct interest to the present effort.

The approach used to determine crop response was a dynamic matrix. The yield loss was expressed as a function of multiple stress assessments throughout the growing season. In this study, actual experimental data were not collected by the investigators. Air quality data and corresponding information on yield or biomass were obtained from several other investigators in various geographic locations of the US. Corresponding multivariate regression models were as follows:

1. The alfalfa model was polynomial:

$$y = ax + bx^2 + cx^3$$

where

y = actual loss in biomass
x = sum of hourly average $O_3$ concentrations

2. The corn, wheat, and potato models were all multivariate linear:

$$y = \Sigma a_i x_i$$

where

$y$ = season yield loss

$x_1 = O_3$ dose statistics

These models were developed from non-Minnesota data and then used through substitution with the Minnesota air quality data to estimate the crop loss for that state.

Different approaches to quantification of plant growth and yield responses to air pollutants are described in Oshima and Gallavan (1980). Plant age and pollutant dose interaction were investigated using factorial design experiments in terms of plant dry weight. It appears that the linear component of the ozone dose and plant interaction is highly significant. Factorial experimental designs, however, do not allow a detailed analysis of the dose-response relationship between the pollutants and the vegetation.

Another interesting model briefly mentioned here is the Richards function:

$$W = A(1 + e^{(b-kt)})^{-1/n}$$

where

W is the dependent variable

t is the independent variable

A,b,k,n are the constants.

It should be noted that a very similar function has been in use since the early 1970s by M. Nosal and A.H. Legge (Legge et al. 1978:115) to describe the annual basal area increment of the lodgepole pine in the sour gas corridors of the AMOCO Canada Sour Gas Plant in the Whitecourt study area of Alberta.

A large number of articles on crop loss assessment are to be found in the proceedings of the E.C. Stakman Commemorative Symposium (P.S. Teng and S.V. Krupa, co-ordinators), held at the University of Minnesota, St. Paul, Minnesota in 1980. However, except for the papers reviewed previously (Heck et al. 1980; Oshima and Gallavan 1980; Heagle

and Heck 1980) , other contributions to the above-mentioned proceedings are not directly concerned with mathematical modelling of air pollutant-plant response relationships and hence are not reviewed here.

## 3. ANALYTICAL PROBABILISTIC MODEL

Many of the mathematical models used in pollutant dose-vegetation response studies were discussed in the previous section. They have the following common deficiencies:

1. They relate to simplified situations of acute exposures or steady state chronic exposures.
2. Given the simplistic approach to data collection as described in item 1 above, these models are rather poor (usually linear) in terms of their mathematical validity.

One of the purposes of the present project was to develop and verify a suitable model with a set of data describing the artificial exposures of soybeans to $SO_2$ and $O_3$ in open-top field chambers in Minnesota. The data were supplied by Dr. S.V. Krupa of the University of Minnesota.

### 3.1 DATA DESCRIPTION

Soybeans (Glycine max) were grown in ambient plots and in open-top field chambers with either filtered or unfiltered air. Ozone and/or sulphur dioxide were artificially dispensed to some of the chambers using a computerised monitoring and dispensing system. The $O_3$ and $SO_2$ concentrations were maintained within the chambers to simulate ambient air quality measurements in the study area as reflected by a nearby air quality monitoring site (and to exceed such data in the case of $SO_2$).

The air quality and plant response data from the following list of treatments were used in the present study (identification codes appear in brackets):

1. six chambers with filtered air to which $SO_2$ was artificially dispensed (chambers A5, A6, C2, C3, D6, and E1);
2. six chambers with filtered air to which $O_3$ was artificially dispensed (chambers B1, C4, D3, E3, and E5); and

3. residual treatments consisting of ambient plot (B2) with no chamber; and chambers with unfiltered (A3) and filtered (A1, B3, D1, and D5) air.

The raw air quality data were supplied on a standard computer magnetic tape. The data file size was about four megabytes. For this reason, the raw data were reduced for each chamber into a chamber regime description which included a listing of each pollutant episode, when it occurred (Julian day), cumulative integral of the pollutant episodes, and the peak pollutant concentration. These chamber regimes are summarised in Tables 7 to 30 appearing in Appendix 6.3.

The plant response data for each chamber included the following variables:

1. plants per row;
2. pods per row;
3. seeds per row;
4. pods per plant;
5. seeds per plant;
6. seed weight per row;
7. seed weight per plant; and
8. thousand seed weight.

For each chamber and for each variable, six values corresponding to six plant rows within the chamber were given. All these rows represent replication of the same treatment and are not useful for response surface modelling. Hence, row values were averaged for each chamber. A summary of plant response data is given in Table 5. For the final dose-response analysis the following variables were selected:

1. number of pods per plant;
2. number of seeds per plant;
3. seed weight per plant; and
4. thousand seed weight.

In order to visualise the dynamic flux and episodic character of the pollutant fumigations, the time series of peak pollutant concentrations (in ppb) were plotted against time (Julian day). These

graphs for various chambers with dispensed $O_3$ and $SO_2$ are included as Figures 1 to 9.

## 3.2 POLLUTANT DOSE QUANTIFICATION

The episodicity of pollutant concentration fluxes in air quality data has long been recognised and it is well documented in our data (see Tables 7 to 30). The data from the Minnesota experiment consist of accurate computer modelling of ambient air in the study area, as well as episodic dynamic flux artificial fumigations of $O_3$ and $SO_2$ over one growing season (about 115 days). The data give exact concentrations of $O_3$ and $SO_2$ in parts per billion (ppb) several times within and for each hour of the experiment. Given this vast amount of data, it was necessary to compress the available information on the $O_3$ and $SO_2$ concentrations into as few parameters as possible with sufficiently high information density in order to capture all necessary variations and details.

After many attempts and trials--closely integrated with the model development--the following dose parameters appeared to be the most suitable to capture the dose-response relationship:

$x_1$ = number of episodes, integral of the concentration (in ppb), and the episode duration exceeding 1

$x_2 = \int_{t_1}^{t_2} c(t)dt$ = integral of the concentration and the duration of each episode, cumulative through the duration of the experiment

$x_3 = \max_{t_1<t<t_2} c(t)$ = peak concentration in ppb

where

$c(t)$ = pollutant concentration at time t

$t_1$ = time at the beginning of the overall experiment

$t_2$ = time at the end of the overall experiment

These parameters were calculated for all the available data and then used within the probabilistic model. The detailed tables of numerical values of the pollutant integral, peak, and the number of episodes are included in Tables 7 to 30.

## 3.3 MODEL DERIVATIONS

It is well known that, under general field conditions, given the dynamic flux and the episodic character of pollutant concentrations, vegetation response to pollutant exposure is intrinsically non-linear. Therefore, the failure resulting from the use of a multivariate linear model at the early stages of this study was not surprising. Subsequently, many other non-linear models were tested. These included exponential, logarithmic, arcsin, and arctangent functions, as well as many others. Among all the models tested, the best fit was obtained through the use of a mixed multivariate polynomial-Fourier regression model:

$$R = \sum_{i=1}^{3} \sum_{n} a_i^{(n)} x_i^n + \sum_{i=1}^{3} \sum_{m} b_i^{(m)} \sin \omega_m x_i$$

where

R = plant response (number of pods per plant, number of seeds per plant, seed weight per plant, number of seeds per plant, thousand seed weight)

$x_1$= number of pollutant episodes

$x_2$= cumulative integral of the pollutant episodes (concentration and duration)

$x_3$= peak pollutant concentration

$a_i^{(n)}$, $b_i^{(m)}$ are the model parameters

The parameters $a_i^{(m)}$ and $b_i^{(m)}$ were estimated using the least squares approach:

$$\min SSQ = \left(R - \sum_{i=1}^{3} \sum_{n} a_i^{(n)} x_i^n - \sum_{i-1}^{3} \sum_{m} b_i^{(m)} \sin \omega_m x_i\right)^2$$

The numerical results of this procedure are included in Tables 2 to 4.

The actual degree of the polynomial (range of the subscript n in the first double sum) and the number of sin terms (range of the subscript m in the second double sum) varied depending on the plant

response type and pollutant type. In general, however, the polynomial degree $n \leq 2$ and sin degree $m \leq 1$ for this experiment and $\omega_m = 1$ were appropriate. It is believed that for more complex experiments with more varied regimes of fumigations, higher degrees of m and n will be needed. However, it is still very likely that the above-mentioned model will provide a good fit. It may be possible that for more complex experimental designs both the functions sin and cos will be needed in the Fourier part of the model. It is also possible that a straight polynomial or straight Fourier model would fit, but only at the expense of a high number of parameters and a high degree of polynomials.

## 3.4 NUMERICAL ANALYSIS OF POLLUTANT EXPOSURE AND PLANT RESPONSE

The following is a synopsis of the numerical regression models obtained after least square fitting. The meaning of the symbols is as follows:

$y$ = specific plant response parameter

$x_1$ = number of pollutant episodes

$x_2$ = cumulative integral of the pollutant episodes (concentration and duration)

$x_3$ = peak pollutant concentration

A. Fumigation Type: Chamber Dispensed $SO_2$ Treatment

1. Plant response: number of pods per plant

$$y = 290 - 18.7x_1 - 0.0043x_2 - 0.0131x_3 + 0.354x_1^2$$

2. Plant response: seed weight per plant

$$y = 82.6 - 5.80x_1 + 0.0016x_2 + 0.017x_3 + 0.106x_1^2$$

3. Plant response: number of seeds per plant

$$y = 626 - 39.3x_1 - 0.0121x_2 - 0.0950x_3 + 0.753x_1^2$$

4. Plant response: thousand seed weight

$$y = -174 + 13.4x_1 + 0.0471x_2 + 0.497x_3 - 0.326x_1^2$$

B. Fumigation Type: Chamber Dispensed $O_3$ Treatment

1. Plant response: number of pods per plant

$$y = 0.142 + 1.42x_1 + 0.0002x_2 - 0.273x_3 - 5.64\sin x_2$$

2. Plant response: seed weight per plant

$$y = 28.0-0.161x_1+0.0001x_2-2.05\sin x_2-1.79\sin x_3$$

3. Plant response: number of seeds per plant

$$y = 43.3+1.45x_1+0.0001x_2-0.289x_3-10.5\sin x_2$$

4. Plant response: thousand seed weight

$$y = 331-1.68x_1-0.0001x_2-4.16\sin x_2-16.6\sin x_3$$

C. Fumigation Type: Residual-Ambient, Unfiltered, and Filtered Air

1. Plant response: pods per plant

$$y = 438-8.30x_1-0.154x_2-0.213x_3-0.0154x_6$$

2. Plant response: seed weight per plant

$$y = 180-3.36x_1-0.0863x_2-0.0847x_3-0.0116x_6$$

3. Plant response: number of seeds per plant

$$y = 35.5-0.0069x_2-0.0421x_3+0.0010x_5-0.037x_6$$

4. Plant response: thousand seed weight

$$y = 1601-26.9x_1-0.581x_2-0.631x_3-0.0016x_5$$

The meaning of the independent variables is as follows:

$x_1$ = number of episodes of $SO_2$

$x_2$ = integral of the $SO_2$ concentration

$x_3$ = peak of the $SO_2$ concentration

$x_4$ = number of episodes of $O_3$

$x_5$ = integral of the $O_3$ concentration

$x_6$ = peak of the $O_3$ concentration

Table 1 summarises the accuracy of the model in terms of the coefficient of determination $R^2$. As shown by the table, it appears that the mixed multivariate polynomial-Fourier regression model fits the given data very well. However, a serious limitation must be recognized. All the fumigation types have been based on only six different fumigation regimes and, therefore, all the dose-response scattergrams are scarely populated (six points). It is not very difficult to obtain a good fit under such conditions. For a proper numerical analysis one

Table 1. Summary of accuracy of numerical regression model.

| Plant Response | Fumigation Type | | |
|---|---|---|---|
| | $SO_2$ | $O_3$ | Residual (A+UF+F air[a]) |
| Number of pods per plant | 96.4 | 99.8 | 97.2 |
| Seed weight per plant | 98.4 | 98.7 | 99.8 |
| Number of seeds per plant | 99.1 | 98.5 | 97.5 |
| Thousand seed weight | 95.9 | 85.5 | 92.8 |

[a] A = ambient; UF= unfiltered; F = filtered

would need many more widely varied fumigation regimes. This information was not available in the Minnesota experiment. However, at the time of this study, it appears that our data is the best available set. For example, since the NCLAN data scattergrams contain only four to five points, they cannot be considered to be any more satisfactory.

## 4. RECOMMENDATIONS FOR EXPERIMENTAL DESIGN AND PREDICTION ANALYSIS OF AIR POLLUTANT-INDUCED PLANT RESPONSE

Success in relating air quality data to the actual response of terrestrial ecosystems seems to be persistently elusive, defying the efforts of many researchers. One reason appears to be the continuing need to find an appropriate experimental design for the investigation of pollutant dose-vegetation response relationships under field conditions. The following recommendations can be derived from the three previous chapters of this report:

1. Either an open-top chamber system with artificial pollutant fumigations or appropriate field plots exposed simply to the ambient air may be used as long as the following two requirements (items 2 and 3) are satisfied. However, since it is much more difficult to satisfy these requisites under field conditions, from a practical viewpoint a chamber system may be preferable.
2. The artificial pollutant dispensing system must provide exposures which are statistically similar to the real, episodic nature and to the dynamic flux of the natural pollutant exposure regimes. Using steady state exposures (constant concentrations or constant concentration differentials over exposure duration such as is being done by NCLAN) may be theoretically interesting but the findings of such projects have no actual bearing in the real word. Similarly, oversimplified assumptions about the statistical nature and distribution of the pollutant concentrations (e.g., lognormal distribution) are not valid.
3. The plant response generally depends on many pollutant dose quantifiers, such as the integral of the concentration and exposure duration, frequency of exposures, and size of the peaks. In this respect, the plant response should be viewed as a multidimensional surface. It is very important to use an experimental design having a broad range of exposure regimes in

terms of pollutant quantification (i.e., many regimes with various levels of peaks and frequencies of occurrence, various concentration integrals, etc.). Such intensive design is much more important than an extensive design which widely replicates a few comparable exposure regimes on many plants and different species of the same plant. This concept has been best expressed in Krupa and Teng (1982): "Defining a response surface demands...response surface methodology which in general emphasizes the number of treatments over number of replications." Unfortunately, all of the experiments reviewed in Section 2 of this report grossly violate this requirement. There appear to be no data currently available from satisfactorily designed experiments. Therefore, any improvement of the models described here must await a better data base.

## 5. REFERENCES

Benson, F.J., S.V. Krupa, P.S. Teng, and D.E. Welsch. 1982. Economic assessment of air pollution damage to agricultural and silvicultural crops in Minnesota: final report. Riseville, Minnesota: Minnesota Pollution Control Agency. 270 pp.

Berger, A., J.L. Melice, and Cl. Demuth. 1982. Statistical distributions of daily and high atmospheric $SO_2$ concentrations. Atmospheric Environment 16(12): 2863-2877.

Heagle, A.S. and W.W. Heck. 1980. Field methods to assess crop losses due to oxidant air pollutants. Proceedings of the E.C. Stakman Commemorative Symposium, P.S. Teng and S.V. Krupa, co-ordinators. 1980 November; University of Minnesota, St. Paul, Minnesota; pp. 296-305.

Heck, W.W., R.I. Larsen, and A.S. Heagle. 1980. Measuring the acute dose-response of plants to ozone. Proceedings of the E.C. Stakman Commemorative Symposium, P.S. Teng and S.V. Krupa, co-ordinators. 1980 November; University of Minnesota, St. Paul, Minnesota; pp. 32-49.

Heck, W.W., O.C. Taylor, R. Adams, G. Bingham, J. Miller, E. Preston, and L. Weinstein. 1982. Assessment of crop loss from ozone. Journal of the Air Pollution Control Association 32(40): 353-361.

Kercher, J.R. and G.E. Bingham. 1982. Approaches for modelling crop-pollutant interactions in the NCLAN program. Proceedings of the 75th Annual Meeting of the Air Pollution Control Association. New Orleans, Louisiana; 82-69.3.

Krupa, S.V. and P.S. Teng. 1982. Uncertainties in estimating ecological effects of air pollutants. Proceedings of the 75th Annual Meeting of the Air Pollution Control Association. New Orleans, Louisiana; 82-6.1:1-10.

Larsen, R.I., A.S. Heagle, and W.W. Heck. 1983. An air quality data analysis system for interrelating effects, standards, and needed source reductions. Part 7: An $O_3$-$SO_2$ leaf injury mathematical model. Journal of the Air Pollution Control Association 33(3):198-207.

Larsen, R.I., T.C. Curran, and W.F. Hunt, Jr. 1980. An air quality data analysis system for interrelating effects, standards, and needed source reductions. Part 6: Calculating concentration reductions needed to achieve the new national ozone standard. Journal of the Air Pollution Control Association 30(6): 662-668.

Larsen, R.I. and W.W. Heck. 1976. An air quality data analysis system for interrelating effects, standards, and needed source reductions. Part 3: Vegetation injury. Journal of the Air Pollution Control Association 26(4): 325-333.

Lefohon, A.S. and H.M. Benedict. 1982. Development of mathematical index that describes ozone concentration, frequency and duration. Atmospheric Environment 16(10): 2529-2532.

Legge, A.H., D.R. Jacques, G.W. Harvey, H.R. Krouse, H.M. Brown, E.C. Rhodes, M. Nosal, et al. 1978. Sulphur gas emissions in the boreal foreast. University of Calgary, Kananaskis Environmental Sciences Centre. 615 pp.

Male, L.M. 1982. An experimental method for predicting a plant yield response to pollution time series. Atmospheric Environment 16(9): 2247-2252.

Nystrom, S.D., R.C. Hendrickson, G.C. Pratt, and S.V. Krupa. 1982. A computerized open-top field chamber system for exposing plants to air pollutants. Agriculture and Environment 7:213-221.

Oshima, R.J. and R.E. Gallavan. 1980. Experimental designs for the quantification of crop growth and yield responses from air pollutants. In Proceedings of E.C. Stakman Commemorative Symposium, P.S. Teng and S.V. Krupa, co-ordinators. University of Minnesota, St. Paul, Minnesota; pp. 63-70.

Pratt, G.C. 1983. Effects of simulated ozone and sulfur dioxide fumigations on soybeans in open-top field chambers. Proceedings of the 76th Annual Meeting of the Air Pollution Control Association. Atlanta, Georgia; 83-2.1:1-15.

# 6. APPENDICES

## 6.1 REGRESSION ANALYSIS OF DATA ON PLANT RESPONSE TO AIR QUALITY

Tables 2 to 4 present the numerical results of a regression analysis of data on plant response to $SO_2$, $O_3$, and residual-ambient, unfiltered, and filtered air.

Table 2. Regression analysis of plant response to dispensed $SO_2$.

Fumigation type:dispensed SO2

Chambers:A5,A6,C2,C3,D6,E1

Plant response data:number of pods per plant
seed weight per plant
number of seeds per plant
thousand seed weight

Air quality data:Number of episodes (EPISODNO)
Integral of the concentration of SO2 (INTEGRAL)
Peak concentration of SO2 (PEAK)

Mathematical model:Multivariate polynomial model of degree 2

REGRESSION ANALYSIS OF PODS PER PLANT

THE REGRESSION EQUATION IS
Y = 290. - 18.7 X1 -0.0043 X2
-0.0131 X3 + 0.354 X4

| | COLUMN | COEFFICIENT | ST. DEV. OF COEF. | T-RATIO = COEF/S.D. |
|---|---|---|---|---|
| | -- | 289.9 | 116.2 | 2.49 |
| X1 | EPISODNO | -18.741 | 8.789 | -2.13 |
| X2 | INTEGRAL | -0.004316 | 0.007498 | -0.58 |
| X3 | PEAK | -0.01306 | 0.06974 | -0.19 |
| X4 | C8 | 0.3540 | 0.1716 | 2.06 |

THE ST. DEV. OF Y ABOUT REGRESSION LINE IS
S = 1.996
WITH ( 6- 5) = 1 DEGREES OF FREEDOM

R-SQUARED = 96.4 PERCENT
R-SQUARED = 81.9 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

| DUE TO | DF | SS | MS=SS/DF |
|---|---|---|---|
| REGRESSION | 4 | 105.790 | 26.447 |
| RESIDUAL | 1 | 3.983 | 3.983 |
| TOTAL | 5 | 109.772 | |

continued ...

Table 2. Continued.

FURTHER ANALYSIS OF VARIANCE
SS EXPLAINED BY EACH VARIABLE WHEN ENTERED IN THE ORDER GIVEN

| DUE TO | DF | SS |
|---|---|---|
| REGRESSION | 4 | 105.790 |
| EPISODNO | 1 | 86.333 |
| INTEGRAL | 1 | 1.339 |
| PEAK | 1 | 1.166 |
| C8 | 1 | 16.952 |

DURBIN-WATSON STATISTIC = 1.35

REGRESSION ANALYSIS OF SEED WEIGHT PER PLANT

THE REGRESSION EQUATION IS
Y = 82.6 - 5.80 X1 +0.0016 X2
+0.0170 X3 + 0.106 X4

| | COLUMN | COEFFICIENT | ST. DEV. OF COEF. | T-RATIO = COEF/S.D. |
|---|---|---|---|---|
| | -- | 82.58 | 19.00 | 4.35 |
| X1 | EPISODNO | -5.797 | 1.437 | -4.04 |
| X2 | INTEGRAL | 0.001553 | 0.001226 | 1.27 |
| X3 | PEAK | 0.01699 | 0.01140 | 1.49 |
| X4 | C8 | 0.10620 | 0.02805 | 3.79 |

THE ST. DEV. OF Y ABOUT REGRESSION LINE IS
S = 0.3262
WITH ( 6- 5) = 1 DEGREES OF FREEDOM

R-SQUARED = 98.4 PERCENT
R-SQUARED = 92.2 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

| DUE TO | DF | SS | MS=SS/DF |
|---|---|---|---|
| REGRESSION | 4 | 6.7021 | 1.6755 |
| RESIDUAL | 1 | 0.1064 | 0.1064 |
| TOTAL | 5 | 6.8085 | |

continued ...

Table 2. Continued.

FURTHER ANALYSIS OF VARIANCE
SS EXPLAINED BY EACH VARIABLE WHEN ENTERED IN THE ORDER GIVEN

| DUE TO | DF | SS |
|---|---|---|
| REGRESSION | 4 | 6.7021 |
| EPISODNO | 1 | 4.2213 |
| INTEGRAL | 1 | 0.0346 |
| PEAK | 1 | 0.9207 |
| C8 | 1 | 1.5255 |

DURBIN-WATSON STATISTIC = 1.35

REGRESSION ANALYSIS OF THE NUMBER OF SEEDS PER PLANT

THE REGRESSION EQUATION IS
Y = 626. - 39.3 X1 -0.0121 X2
-0.0950 X3 + 0.753 X4

| | COLUMN | COEFFICIENT | ST. DEV. OF COEF. | T-RATIO = COEF/S.D. |
|---|---|---|---|---|
| | -- | 625.9 | 105.4 | 5.94 |
| X1 | EPISODNO | -39.302 | 7.967 | -4.93 |
| X2 | INTEGRAL | -0.012116 | 0.006796 | -1.78 |
| X3 | PEAK | -0.09501 | 0.06322 | -1.50 |
| X4 | C8 | 0.7527 | 0.1555 | 4.84 |

THE ST. DEV. OF Y ABOUT REGRESSION LINE IS
S = 1.809
WITH ( 6- 5) = 1 DEGREES OF FREEDOM

R-SQUARED = 99.1 PERCENT
R-SQUARED = 95.5 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

| DUE TO | DF | SS | MS=SS/DF |
|---|---|---|---|
| REGRESSION | 4 | 362.732 | 90.683 |
| RESIDUAL | 1 | 3.272 | 3.272 |
| TOTAL | 5 | 366.004 | |

continued ...

Table 2. Continued.

FURTHER ANALYSIS OF VARIANCE
SS EXPLAINED BY EACH VARIABLE WHEN ENTERED IN THE ORDER GIVEN

| DUE TO | DF | SS |
|---|---|---|
| REGRESSION | 4 | 362.732 |
| EPISODNO | 1 | 280.814 |
| INTEGRAL | 1 | 5.229 |
| PEAK | 1 | 0.063 |
| C8 | 1 | 76.626 |

DURBIN-WATSON STATISTIC = 1.35

REGRESSION ANALYSIS OF THE THOUSAND SEED WEIGHT

THE REGRESSION EQUATION IS
Y = - 174. + 13.4 X1 +0.0471 X2
+ 0.497 X3 - 0.326 X4

| | COLUMN | COEFFICIENT | ST. DEV. OF COEF. | T-RATIO = COEF/S.D. |
|---|---|---|---|---|
| | -- | -174.0 | 209.7 | -0.83 |
| X1 | EPISODNO | 13.40 | 15.85 | 0.85 |
| X2 | INTEGRAL | 0.04712 | 0.01352 | 3.48 |
| X3 | PEAK | 0.4973 | 0.1258 | 3.95 |
| X4 | C8 | -0.3258 | 0.3095 | -1.05 |

THE ST. DEV. OF Y ABOUT REGRESSION LINE IS
S = 3.600
WITH ( 6- 5) = 1 DEGREES OF FREEDOM

R-SQUARED = 95.9 PERCENT
R-SQUARED = 79.5 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

| DUE TO | DF | SS | MS=SS/DF |
|---|---|---|---|
| REGRESSION | 4 | 303.24 | 75.81 |
| RESIDUAL | 1 | 12.96 | 12.96 |
| TOTAL | 5 | 316.19 | |

continued ...

Table 2. Concluded.

FURTHER ANALYSIS OF VARIANCE
SS EXPLAINED BY EACH VARIABLE WHEN ENTERED IN THE ORDER GIVEN

| DUE TO | DF | SS |
|---|---|---|
| REGRESSION | 4 | 303.24 |
| EPISODNO | 1 | 57.61 |
| INTEGRAL | 1 | 41.91 |
| PEAK | 1 | 189.35 |
| C8 | 1 | 14.36 |

DURBIN-WATSON STATISTIC = 1.35

Table 3. Regression analysis of plant response to dispensed $O_3$.

Fumigation type:dispensed 03

Chambers:E3,D3,D4,B1,C4,E5

Plant response data:number of pods per plant
seed weight per plant
number of seeds per plant
thousand seed weight

Air quality data:number of episodes (EPISODNO)
integral of the concentration of 03 (INTEGRAL)
peak concentration of 03 (PEAK)

Mathematical model:mixed multivariate linear and Fourier series type

REGRESSION ANALYSIS OF PODS PER PLANT

THE REGRESSION EQUATION IS
Y = 0.142 + 1.42 X1 +0.0002 X2
- 0.273 X3 - 5.64 X4

| | COLUMN | COEFFICIENT | ST. DEV. OF COEF. | T-RATIO = COEF/S.D. |
|---|---|---|---|---|
| | -- | 0.142 | 5.063 | 0.03 |
| X1 | EPISODNO | 1.4162 | 0.2207 | 6.42 |
| X2 | INTEGRAL | 0.00019778 | 0.00003018 | 6.55 |
| X3 | PEAK | -0.27267 | 0.04462 | -6.11 |
| X4 | SINC6 | -5.6438 | 0.3251 | -17.36 |

THE ST. DEV. OF Y ABOUT REGRESSION LINE IS
S = 0.4107
WITH ( 6- 5) = 1 DEGREES OF FREEDOM

R-SQUARED = 99.8 PERCENT
R-SQUARED = 98.9 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

| DUE TO | DF | SS | MS=SS/DF |
|---|---|---|---|
| REGRESSION | 4 | 73.4468 | 18.3617 |
| RESIDUAL | 1 | 0.1686 | 0.1686 |
| TOTAL | 5 | 73.6155 | |

continued ...

Table 3. Continued.

FURTHER ANALYSIS OF VARIANCE
SS EXPLAINED BY EACH VARIABLE WHEN ENTERED IN THE ORDER GIVEN

| DUE TO | DF | SS |
|---|---|---|
| REGRESSION | 4 | 73.4468 |
| EPISODNO | 1 | 7.3320 |
| INTEGRAL | 1 | 0.0017 |
| PEAK | 1 | 15.2911 |
| SINC6 | 1 | 50.8221 |

DURBIN-WATSON STATISTIC = 2.48

REGRESSION ANALYSIS OF SEED WEIGHT PER PLANT

THE REGRESSION EQUATION IS
Y = 28.0 - 0.161 X1 +0.0000 X2
- 2.05 X3 - 1.79 X4

| | COLUMN | COEFFICIENT | ST. DEV. OF COEF. | T-RATIO = COEF/S.D. |
|---|---|---|---|---|
| | -- | 28.029 | 3.235 | 8.66 |
| X1 | EPISODNO | -0.16079 | 0.03804 | -4.23 |
| X2 | INTEGRAL | 0.00000372 | 0.00001781 | 0.21 |
| X3 | SINC6 | -2.0464 | 0.2443 | -8.38 |
| X4 | SINC7 | -1.7863 | 0.3193 | -5.60 |

THE ST. DEV. OF Y ABOUT REGRESSION LINE IS
S = 0.4008
WITH ( 6- 5) = 1 DEGREES OF FREEDOM

R-SQUARED = 98.7 PERCENT
R-SQUARED = 93.5 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

| DUE TO | DF | SS | MS=SS/DF |
|---|---|---|---|
| REGRESSION | 4 | 12.2457 | 3.0614 |
| RESIDUAL | 1 | 0.1606 | 0.1606 |
| TOTAL | 5 | 12.4063 | |

continued ...

Table 3. Continued.

FURTHER ANALYSIS OF VARIANCE
SS EXPLAINED BY EACH VARIABLE WHEN ENTERED IN THE ORDER GIVEN

| DUE TO | DF | SS |
|---|---|---|
| REGRESSION | 4 | 12.2457 |
| EPISODNO | 1 | 0.0114 |
| INTEGRAL | 1 | 0.3217 |
| SINC6 | 1 | 6.8840 |
| SINC7 | 1 | 5.0285 |

DURBIN-WATSON STATISTIC = 2.72

REGRESSION ANALYSIS OF THE NUMBER OF SEEDS PER PLANT

THE REGRESSION EQUATION IS
Y = 43.3 + 1.45 X1 +0.0002 X2
- 0.289 X3 - 10.5 X4

| | COLUMN | COEFFICIENT | ST. DEV. OF COEF. | T-RATIO = COEF/S.D. |
|---|---|---|---|---|
| | -- | 43.34 | 26.26 | 1.65 |
| X1 | EPISODNO | 1.452 | 1.145 | 1.27 |
| X2 | INTEGRAL | 0.0002406 | 0.0001565 | 1.54 |
| X3 | PEAK | -0.2887 | 0.2314 | -1.25 |
| X4 | SINC6 | -10.459 | 1.686 | -6.20 |

THE ST. DEV. OF Y ABOUT REGRESSION LINE IS
S = 2.130
WITH ( 6- 5) = 1 DEGREES OF FREEDOM

R-SQUARED = 98.5 PERCENT
R-SQUARED = 92.3 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

| DUE TO | DF | SS | MS=SS/DF |
|---|---|---|---|
| REGRESSION | 4 | 291.907 | 72.977 |
| RESIDUAL | 1 | 4.536 | 4.536 |
| TOTAL | 5 | 296.443 | |

continued ...

Table 3. Continued.

FURTHER ANALYSIS OF VARIANCE
SS EXPLAINED BY EACH VARIABLE WHEN ENTERED IN THE ORDER GIVEN

| DUE TO | DF | SS |
|---|---|---|
| REGRESSION | 4 | 291.907 |
| EPISODNO | 1 | 14.105 |
| INTEGRAL | 1 | 0.184 |
| PEAK | 1 | 103.091 |
| SINC6 | 1 | 174.527 |

DURBIN-WATSON STATISTIC = 2.48

REGRESSION ANALYSIS OF THE THOUSAND SEED WEIGHT

THE REGRESSION EQUATION IS
Y = 331. - 1.68 X1 -0.0001 X2
- 4.16 X3 - 16.6 X4

| | COLUMN | COEFFICIENT | ST. DEV. OF COEF. | T-RATIO = COEF/S.D. |
|---|---|---|---|---|
| | -- | 331.09 | 78.97 | 4.19 |
| X1 | EPISODNO | -1.6763 | 0.9287 | -1.81 |
| X2 | INTEGRAL | -0.0001170 | 0.0004349 | -0.27 |
| X3 | SINC6 | -4.158 | 5.965 | -0.70 |
| X4 | SINC7 | -16.640 | 7.794 | -2.13 |

THE ST. DEV. OF Y ABOUT REGRESSION LINE IS
S = 9.784
WITH ( 6- 5) = 1 DEGREES OF FREEDOM

R-SQUARED = 85.1 PERCENT
R-SQUARED = 25.7 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

| DUE TO | DF | SS | MS=SS/DF |
|---|---|---|---|
| REGRESSION | 4 | 548.20 | 137.05 |
| RESIDUAL | 1 | 95.74 | 95.74 |
| TOTAL | 5 | 643.93 | |

continued ...

Table 3. Concluded.

FURTHER ANALYSIS OF VARIANCE
SS EXPLAINED BY EACH VARIABLE WHEN ENTERED IN THE ORDER GIVEN

| DUE TO | DF | SS |
|---|---|---|
| REGRESSION | 4 | 548.20 |
| EPISODNO | 1 | 79.57 |
| INTEGRAL | 1 | 23.17 |
| SINC6 | 1 | 9.13 |
| SINC7 | 1 | 436.33 |

DURBIN-WATSON STATISTIC = 2.72

Table 4. Regression analysis of plant response to residual ambient, unfiltered, and filtered air.

Fumigation type:residual - ambient, unfiltered and filtered air

Chambers:A1,A3,B2,D5,B3,D1

Plant response data:number of pods per plant
seed weight per plant
number of seeds per plant
thousand seed weight

Air quality data:number of episodes of SO2 and O3
integral of the concentration of SO2 and O3
peak concentration of SO2 and O3

Mathematical model:multivariate linear regression

REGRESSION ANALYSIS OF PODS PER PLANT

THE REGRESSION EQUATION IS
Y = 438. - 8.30 X1 - 0.154 X2
- 0.213 X3 -0.0154 X4

| | COLUMN | COEFFICIENT | ST. DEV. OF COEF. | T-RATIO = COEF/S.D. |
|---|---|---|---|---|
| | -- | 438.21 | 88.90 | 4.93 |
| X1 | EPNO/SO2 | -8.300 | 1.857 | -4.52 |
| X2 | INT/SO2 | -0.15414 | 0.03707 | -4.16 |
| X3 | PEAK/SO2 | -0.21301 | 0.05168 | -4.12 |
| X4 | PEAK/O3 | -0.01543 | 0.01988 | -0.78 |

THE ST. DEV. OF Y ABOUT REGRESSION LINE IS
S = 1.926
WITH ( 6- 5) = 1 DEGREES OF FREEDOM

R-SQUARED = 97.2 PERCENT
R-SQUARED = 85.9 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

| DUE TO | DF | SS | MS=SS/DF |
|---|---|---|---|
| REGRESSION | 4 | 127.720 | 31.930 |
| RESIDUAL | 1 | 3.710 | 3.710 |
| TOTAL | 5 | 131.430 | |

continued ...

Table 4. Continued.

FURTHER ANALYSIS OF VARIANCE
SS EXPLAINED BY EACH VARIABLE WHEN ENTERED IN THE ORDER GIVEN

| DUE TO | DF | SS |
|---|---|---|
| REGRESSION | 4 | 127.720 |
| EPNO/SO2 | 1 | 0.021 |
| INT/SO2 | 1 | 64.588 |
| PEAK/SO2 | 1 | 60.875 |
| PEAK/O3 | 1 | 2.235 |

DURBIN-WATSON STATISTIC = 2.34

REGRESSION ANALYSIS OF SEED WEIGHT PER PLANT

THE REGRESSION EQUATION IS
Y = 180. - 3.36 X1 -0.0683 X2
-0.0847 X3 -0.0116 X4

| | COLUMN | COEFFICIENT | ST. DEV. OF COEF. | T-RATIO = COEF/S.D. |
|---|---|---|---|---|
| | -- | 180.432 | 8.718 | 20.70 |
| X1 | EPNO/SO2 | -3.3594 | 0.1801 | -18.65 |
| X2 | INT/SO2 | -0.068295 | 0.003635 | -18.79 |
| X3 | PEAK/SO2 | -0.084747 | 0.005068 | -16.72 |
| X4 | PEAK/O3 | -0.011594 | 0.001950 | -5.95 |

THE ST. DEV. OF Y ABOUT REGRESSION LINE IS
S = 0.1889
WITH ( 6- 5) = 1 DEGREES OF FREEDOM

R-SQUARED = 99.8 PERCENT
R-SQUARED = 99.2 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

| DUE TO | DF | SS | MS=SS/DF |
|---|---|---|---|
| REGRESSION | 4 | 21.78532 | 5.44633 |
| RESIDUAL | 1 | 0.03568 | 0.03568 |
| TOTAL | 5 | 21.82100 | |

continued ...

Table 4. Continued.

FURTHER ANALYSIS OF VARIANCE
SS EXPLAINED BY EACH VARIABLE WHEN ENTERED IN THE ORDER GIVEN

| DUE TO | DF | SS |
|---|---|---|
| REGRESSION | 4 | 21.78532 |
| EPNO/SO2 | 1 | 1.31040 |
| INT/SO2 | 1 | 10.31951 |
| PEAK/SO2 | 1 | 8.89412 |
| PEAK/O3 | 1 | 1.26129 |

DURBIN-WATSON STATISTIC = 2.34

REGRESSION ANALYSIS OF THE NUMBER OF SEEDS PER PLANT

THE REGRESSION EQUATION IS
Y = 35.5 -0.0069 X1 -0.0421 X2
+0.0010 X3 -0.0370 X4

| | COLUMN | COEFFICIENT | ST. DEV. OF COEF. | T-RATIO = COEF/S.D. |
|---|---|---|---|---|
| | -- | 35.54 | 30.72 | 1.16 |
| X1 | INT/SO2 | -0.00687 | 0.03762 | -0.18 |
| X2 | PEAK/SO2 | -0.04209 | 0.08177 | -0.51 |
| X3 | INT/O3 | 0.0010411 | 0.0002343 | 4.44 |
| X4 | PEAK/O3 | -0.03703 | 0.04591 | -0.81 |

THE ST. DEV. OF Y ABOUT REGRESSION LINE IS
S = 4.060
WITH ( 6- 5) = 1 DEGREES OF FREEDOM

R-SQUARED = 97.5 PERCENT
R-SQUARED = 87.6 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

| DUE TO | DF | SS | MS=SS/DF |
|---|---|---|---|
| REGRESSION | 4 | 647.51 | 161.88 |
| RESIDUAL | 1 | 16.49 | 16.49 |
| TOTAL | 5 | 663.99 | |

continued ...

Table 4. Continued.

FURTHER ANALYSIS OF VARIANCE
SS EXPLAINED BY EACH VARIABLE WHEN ENTERED IN THE ORDER GIVEN

| DUE TO | DF | SS |
|---|---|---|
| REGRESSION | 4 | 647.51 |
| INT/SO2 | 1 | 90.14 |
| PEAK/SO2 | 1 | 0.36 |
| INT/O3 | 1 | 546.28 |
| PEAK/O3 | 1 | 10.73 |

DURBIN-WATSON STATISTIC = 2.38

REGRESSION ANALYSIS OF THE THOUSAND SEED WEIGHT

THE REGRESSION EQUATION IS
Y = 1601. - 26.9 X1 - 0.581 X2
- 0.631 X3 -0.0016 X4

| | COLUMN | COEFFICIENT | ST. DEV. OF COEF. | T-RATIO = COEF/S.D. |
|---|---|---|---|---|
| | -- | 1600.6 | 567.9 | 2.82 |
| X1 | EPNO/SO2 | -26.91 | 11.26 | -2.39 |
| X2 | INT/SO2 | -0.5813 | 0.2067 | -2.81 |
| X3 | PEAK/SO2 | -0.6313 | 0.2940 | -2.15 |
| X4 | INT/O3 | -0.0015588 | 0.0006222 | -2.51 |

THE ST. DEV. OF Y ABOUT REGRESSION LINE IS
S = 5.415
WITH ( 6- 5) = 1 DEGREES OF FREEDOM

R-SQUARED = 92.8 PERCENT
R-SQUARED = 63.9 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

| DUE TO | DF | SS | MS=SS/DF |
|---|---|---|---|
| REGRESSION | 4 | 377.18 | 94.29 |
| RESIDUAL | 1 | 29.32 | 29.32 |
| TOTAL | 5 | 406.50 | |

continued ...

Table 4. Concluded.

FURTHER ANALYSIS OF VARIANCE
SS EXPLAINED BY EACH VARIABLE WHEN ENTERED IN THE ORDER GIVEN

| DUE TO | DF | SS |
|---|---|---|
| REGRESSION | 4 | 377.18 |
| EPNO/SO2 | 1 | 134.56 |
| INT/SO2 | 1 | 58.31 |
| PEAK/SO2 | 1 | 0.30 |
| INT/O3 | 1 | 184.00 |

DURBIN-WATSON STATISTIC = 2.50

## 6.2 PLANT RESPONSE DATA

Table 5 provides a summary of plant response data. Table 6 presents the plant response data.

Table 5. Summary of plant response data.[a]

| Chamber | Pl/row | Pod/row | Pod/pl | Seedw/r | Seedw/pl | Seed/row | Seed/pl | Kseedw |
|---|---|---|---|---|---|---|---|---|
| A1 | 23.00 | 763.50 | 33.22 | 248.00 | 10.77 | 1619.67 | 70.32 | 151.07 |
| A2 | 24.83 | 983.33 | 39.60 | 353.82 | 14.28 | 2239.00 | 90.27 | 157.84 |
| A3 | 21.67 | 916.17 | 42.71 | 303.75 | 14.16 | 1967.00 | 91.49 | 154.66 |
| A4 | 24.00 | 1010.17 | 42.36 | 378.80 | 15.89 | 2236.67 | 93.86 | 169.24 |
| A5 | 22.67 | 783.50 | 34.48 | 289.37 | 12.70 | 1762.00 | 77.53 | 161.65 |
| A6 | 24.50 | 900.83 | 36.48 | 355.03 | 14.38 | 1975.67 | 79.97 | 178.98 |
| B1 | 21.67 | 798.33 | 36.90 | 255.60 | 11.84 | 1710.50 | 79.15 | 151.02 |
| B2 | 24.00 | 958.83 | 40.01 | 312.12 | 13.01 | 2098.00 | 87.46 | 148.78 |
| B3 | 22.17 | 789.67 | 34.43 | 262.13 | 11.38 | 1755.00 | 76.11 | 149.38 |
| B4 | 22.67 | 1035.83 | 46.12 | 382.50 | 17.09 | 2282.17 | 101.44 | 166.21 |
| B5 | 21.67 | 818.33 | 38.06 | 270.57 | 12.60 | 1702.67 | 79.28 | 157.20 |
| B6 | 20.50 | 855.67 | 41.67 | 328.30 | 16.26 | 1875.33 | 90.55 | 178.90 |
| C1 | 20.00 | 877.17 | 44.16 | 307.47 | 15.50 | 1896.00 | 95.17 | 162.81 |
| C2 | 21.50 | 978.00 | 46.15 | 341.58 | 16.02 | 2044.67 | 96.99 | 166.75 |
| C3 | 22.00 | 771.33 | 35.70 | 290.17 | 13.53 | 1624.00 | 75.90 | 181.00 |
| C4 | 23.67 | 949.50 | 40.62 | 368.85 | 15.78 | 2070.17 | 89.16 | 180.09 |
| C5 | 19.00 | 725.33 | 38.43 | 268.12 | 14.08 | 1589.00 | 84.10 | 165.73 |
| C6 | 20.83 | 859.00 | 41.56 | 308.50 | 14.78 | 1899.83 | 91.90 | 161.84 |
| D1 | 19.17 | 850.00 | 45.86 | 308.72 | 16.59 | 1859.50 | 100.14 | 165.40 |
| D2 | 23.83 | 896.50 | 38.56 | 322.20 | 13.84 | 1972.67 | 84.82 | 161.40 |
| D3 | 22.50 | 898.17 | 40.47 | 341.52 | 15.39 | 1946.17 | 87.70 | 175.05 |
| D4 | 22.17 | 777.67 | 35.47 | 297.08 | 13.47 | 1656.33 | 75.28 | 178.89 |
| D5 | 24.50 | 842.17 | 34.92 | 306.17 | 12.75 | 1796.67 | 74.59 | 170.07 |
| D6 | 17.83 | 593.33 | 33.46 | 237.85 | 13.36 | 1301.83 | 73.61 | 179.88 |
| E1 | 19.50 | 772.83 | 39.83 | 283.82 | 14.56 | 1655.50 | 85.29 | 171.65 |
| E2 | 16.50 | 765.00 | 45.84 | 288.58 | 17.44 | 1678.17 | 101.65 | 170.06 |
| E3 | 23.67 | 711.67 | 30.26 | 292.90 | 12.43 | 1619.67 | 68.80 | 181.41 |
| E4 | 26.17 | 1154.33 | 45.15 | 421.87 | 16.58 | 2545.50 | 99.74 | 165.46 |
| E5 | 24.83 | 928.33 | 37.85 | 347.88 | 14.18 | 2022.33 | 82.42 | 172.02 |
| E6 | 18.50 | 852.33 | 46.52 | 346.50 | 18.78 | 1848.00 | 100.29 | 186.34 |

[a]All weights expressed in grams. Kseedw = thousand seed weight.

Table 6. Plant response data.[a]

| Chamber | Pl/row | Pod/row | Pod/pl | Seedw/r | Seedw/pl | Seed/row | Seed/pl | Kseedw |
|---|---|---|---|---|---|---|---|---|
| A1 | 25.00 | 923.00 | 36.92 | 326.50 | 13.06 | 2027.00 | 81.08 | 161.08 |
| A1 | 26.00 | 774.00 | 29.77 | 242.50 | 9.33 | 1688.00 | 64.92 | 143.66 |
| A1 | 22.00 | 700.00 | 31.82 | 203.20 | 9.24 | 1386.00 | 63.00 | 146.61 |
| A1 | 19.00 | 535.00 | 28.16 | 159.90 | 8.42 | 1118.00 | 58.84 | 143.02 |
| A1 | 24.00 | 617.00 | 25.71 | 189.60 | 7.90 | 1310.00 | 54.58 | 144.73 |
| A1 | 22.00 | 1032.00 | 46.91 | 366.30 | 16.65 | 2189.00 | 99.50 | 167.34 |
| A2 | 26.00 | 931.00 | 35.81 | 304.60 | 11.72 | 2053.00 | 78.96 | 148.37 |
| A2 | 25.00 | 1048.00 | 41.92 | 376.50 | 15.06 | 2485.00 | 99.40 | 151.51 |
| A2 | 27.00 | 1021.00 | 37.81 | 348.10 | 12.89 | 2225.00 | 82.41 | 156.45 |
| A2 | 23.00 | 683.00 | 29.70 | 254.40 | 11.06 | 1582.00 | 68.78 | 160.81 |
| A2 | 24.00 | 945.00 | 39.38 | 354.50 | 14.77 | 2146.00 | 89.42 | 165.19 |
| A2 | 24.00 | 1272.00 | 53.00 | 484.80 | 20.20 | 2943.00 | 122.63 | 164.73 |
| A3 | 22.00 | 994.00 | 45.18 | 337.90 | 15.36 | 2137.00 | 97.14 | 158.12 |
| A3 | 19.00 | 751.00 | 39.53 | 251.80 | 13.25 | 1585.00 | 83.42 | 158.86 |
| A3 | 19.00 | 932.00 | 49.05 | 296.10 | 15.58 | 1935.00 | 101.84 | 153.02 |
| A3 | 26.00 | 952.00 | 36.62 | 321.40 | 12.36 | 2156.00 | 82.92 | 149.07 |
| A3 | 19.00 | 883.00 | 46.47 | 303.00 | 15.95 | 1906.00 | 100.32 | 158.97 |
| A3 | 25.00 | 985.00 | 39.40 | 312.30 | 12.49 | 2083.00 | 83.32 | 149.93 |
| A4 | 26.00 | 1159.00 | 44.58 | 459.90 | 17.69 | 2680.00 | 103.08 | 171.60 |
| A4 | 17.00 | 768.00 | 45.18 | 290.20 | 17.07 | 1732.00 | 101.88 | 167.55 |
| A4 | 28.00 | 1046.00 | 37.36 | 382.30 | 13.65 | 2306.00 | 82.36 | 165.78 |
| A4 | 25.00 | 1115.00 | 44.60 | 397.80 | 15.91 | 2367.00 | 94.68 | 168.06 |
| A4 | 26.00 | 1034.00 | 39.77 | 391.70 | 15.07 | 2268.00 | 87.23 | 172.71 |
| A4 | 22.00 | 939.00 | 42.68 | 350.90 | 15.95 | 2067.00 | 93.95 | 169.76 |
| A5 | 24.00 | 1108.00 | 46.17 | 464.00 | 19.33 | 2585.00 | 107.71 | 179.50 |
| A5 | 19.00 | 566.00 | 29.79 | 212.70 | 11.19 | 1251.00 | 65.84 | 170.02 |
| A5 | 23.00 | 553.00 | 24.04 | 157.60 | 6.85 | 1125.00 | 48.91 | 140.09 |
| A5 | 19.00 | 740.00 | 38.95 | 260.00 | 13.68 | 1702.00 | 89.58 | 152.76 |
| A5 | 26.00 | 927.00 | 35.65 | 355.10 | 13.66 | 2085.00 | 80.19 | 170.31 |
| A5 | 25.00 | 807.00 | 32.28 | 246.80 | 11.47 | 1824.00 | 72.96 | 157.24 |

continued ...

Table 6. Continued.

| Chamber | Pl/row | Pod/row | Pod/pl | Seedw/r | Seedw/pl | Seed/row | Seed/pl | Kseedw |
|---|---|---|---|---|---|---|---|---|
| A6 | 27.00 | 1290.00 | 47.78 | 497.10 | 18.41 | 2859.00 | 105.89 | 173.87 |
| A6 | 23.00 | 794.00 | 34.52 | 330.40 | 14.37 | 1767.00 | 76.83 | 186.98 |
| A6 | 24.00 | 592.00 | 24.67 | 194.60 | 8.11 | 1220.00 | 50.83 | 159.51 |
| A6 | 25.00 | 1081.00 | 43.24 | 454.60 | 18.18 | 2433.00 | 97.32 | 186.85 |
| A6 | 24.00 | 774.00 | 32.25 | 319.90 | 13.33 | 1671.00 | 69.63 | 191.44 |
| A6 | 24.00 | 874.00 | 36.42 | 333.60 | 13.90 | 1904.00 | 79.33 | 175.21 |
| B1 | 23.00 | 909.00 | 39.52 | 292.00 | 12.70 | 1839.00 | 79.96 | 158.78 |
| B1 | 18.00 | 549.00 | 30.50 | 174.10 | 9.67 | 1012.00 | 56.22 | 172.04 |
| B1 | 23.00 | 777.00 | 33.78 | 246.70 | 10.73 | 1724.00 | 74.96 | 143.10 |
| B1 | 26.00 | 915.00 | 35.19 | 305.60 | 11.75 | 2090.00 | 80.38 | 146.22 |
| B1 | 24.00 | 964.00 | 40.17 | 288.70 | 12.03 | 1992.00 | 83.00 | 144.93 |
| B1 | 16.00 | 676.00 | 42.25 | 226.50 | 14.16 | 1606.00 | 100.38 | 141.03 |
| B2 | 23.00 | 1040.00 | 45.22 | 322.50 | 14.02 | 2310.00 | 100.43 | 139.61 |
| B2 | 24.00 | 863.00 | 35.96 | 264.90 | 11.04 | 1900.00 | 79.17 | 139.42 |
| B2 | 23.00 | 1168.00 | 50.78 | 388.70 | 16.90 | 2551.00 | 110.91 | 152.37 |
| B2 | 26.00 | 1134.00 | 43.62 | 404.00 | 15.54 | 2667.00 | 102.58 | 151.48 |
| B2 | 24.00 | 673.00 | 28.04 | 203.50 | 8.48 | 1498.00 | 62.42 | 135.85 |
| B2 | 24.00 | 875.00 | 36.46 | 289.10 | 12.05 | 1662.00 | 69.25 | 173.95 |
| B3 | 26.00 | 952.00 | 36.62 | 307.60 | 11.83 | 2155.00 | 82.88 | 142.74 |
| B3 | 24.00 | 982.00 | 40.92 | 314.30 | 13.10 | 2316.00 | 96.50 | 135.71 |
| B3 | 14.00 | 256.00 | 18.29 | 70.70 | 5.05 | 494.00 | 35.29 | 143.12 |
| B3 | 23.00 | 717.00 | 31.17 | 249.50 | 10.85 | 1629.00 | 70.83 | 153.16 |
| B3 | 23.00 | 884.00 | 38.43 | 333.10 | 14.48 | 1896.00 | 82.43 | 175.69 |
| B3 | 23.00 | 947.00 | 41.17 | 297.60 | 12.94 | 2040.00 | 88.70 | 145.88 |
| B4 | 26.00 | 1185.00 | 45.58 | 449.40 | 17.28 | 2683.00 | 103.19 | 167.50 |
| B4 | 24.00 | 1206.00 | 50.25 | 473.10 | 19.71 | 2786.00 | 116.08 | 169.81 |
| B4 | 23.00 | 787.00 | 34.22 | 226.70 | 9.86 | 1585.00 | 68.91 | 143.03 |
| B4 | 21.00 | 928.00 | 44.19 | 327.50 | 15.60 | 1797.00 | 85.57 | 182.25 |
| B4 | 23.00 | 934.00 | 40.61 | 328.60 | 14.29 | 2177.00 | 94.65 | 150.94 |
| B4 | 19.00 | 1175.00 | 61.84 | 489.70 | 25.77 | 2665.00 | 140.26 | 183.75 |

continued ...

Table 6. Continued.

| Chamber | Pl/row | Pod/row | Pod/pl | Seedw/r | Seedw/pl | Seed/row | Seed/pl | Kseedw |
|---|---|---|---|---|---|---|---|---|
| B5 | 21.00 | 958.00 | 45.62 | 357.40 | 17.02 | 2193.00 | 104.43 | 162.97 |
| B5 | 21.00 | 678.00 | 32.29 | 211.90 | 10.09 | 1418.00 | 67.52 | 149.44 |
| B5 | 22.00 | 510.00 | 23.18 | 138.30 | 6.29 | 1101.00 | 50.05 | 125.61 |
| B5 | 24.00 | 693.00 | 28.88 | 211.40 | 8.81 | 1207.00 | 50.29 | 175.14 |
| B5 | 20.00 | 938.00 | 46.90 | 303.10 | 15.16 | 1771.00 | 88.55 | 171.15 |
| B5 | 22.00 | 1133.00 | 51.50 | 401.30 | 18.24 | 2526.00 | 114.82 | 158.87 |
| B6 | 32.00 | 1251.00 | 39.09 | 539.90 | 16.87 | 2910.00 | 90.94 | 185.53 |
| B6 | 17.00 | 535.00 | 31.47 | 195.50 | 11.50 | 1125.00 | 66.18 | 173.78 |
| B6 | 14.00 | 449.00 | 32.07 | 160.20 | 11.44 | 925.00 | 66.07 | 173.19 |
| B6 | 24.00 | 984.00 | 41.00 | 378.10 | 15.75 | 2119.00 | 88.29 | 178.43 |
| B6 | 18.00 | 850.00 | 47.22 | 351.50 | 19.53 | 1934.00 | 107.44 | 181.75 |
| B6 | 18.00 | 1065.00 | 59.17 | 404.60 | 22.48 | 2239.00 | 124.39 | 180.71 |
| C1 | 21.00 | 1004.00 | 47.81 | 357.90 | 17.04 | 2245.00 | 106.90 | 159.42 |
| C1 | 24.00 | 965.00 | 40.21 | 313.60 | 13.07 | 2071.00 | 86.29 | 151.42 |
| C1 | 16.00 | 820.00 | 51.25 | 289.80 | 18.11 | 1743.00 | 108.94 | 166.27 |
| C1 | 19.00 | 958.00 | 50.42 | 352.70 | 18.56 | 2113.00 | 111.21 | 166.92 |
| C1 | 23.00 | 906.00 | 39.39 | 328.00 | 14.26 | 2007.00 | 87.26 | 163.43 |
| C1 | 17.00 | 610.00 | 35.88 | 202.80 | 11.93 | 1197.00 | 70.41 | 169.42 |
| C2 | 24.00 | 1135.00 | 47.29 | 410.00 | 17.08 | 2205.00 | 91.88 | 185.94 |
| C2 | 25.00 | 987.00 | 39.48 | 330.60 | 13.22 | 1810.00 | 72.40 | 182.65 |
| C2 | 16.00 | 849.00 | 53.06 | 266.20 | 16.64 | 1830.00 | 114.38 | 145.46 |
| C2 | 22.00 | 984.00 | 44.73 | 387.30 | 17.60 | 2299.00 | 104.50 | 168.46 |
| C2 | 23.00 | 912.00 | 39.65 | 320.30 | 13.93 | 1993.00 | 86.65 | 160.71 |
| C2 | 19.00 | 1001.00 | 52.68 | 335.10 | 17.64 | 2131.00 | 112.16 | 157.25 |
| C3 | 25.00 | 837.00 | 33.48 | 310.20 | 12.41 | 1297.00 | 51.88 | 239.17 |
| C3 | 25.00 | 883.00 | 35.32 | 300.80 | 12.03 | 1939.00 | 77.56 | 155.13 |
| C3 | 18.00 | 688.00 | 38.22 | 265.60 | 14.76 | 1570.00 | 87.22 | 169.17 |
| C3 | 25.00 | 691.00 | 27.64 | 258.40 | 10.34 | 1526.00 | 61.04 | 169.33 |
| C3 | 18.00 | 847.00 | 47.06 | 354.20 | 19.68 | 1917.00 | 106.50 | 184.77 |
| C3 | 21.00 | 682.00 | 32.48 | 251.80 | 11.99 | 1495.00 | 71.19 | 168.43 |

continued ...

Table 6. Continued.

| Chamber | Pl/row | Pod/row | Pod/pl | Seedw/r | Seedw/pl | Seed/row | Seed/pl | Kseedw |
|---|---|---|---|---|---|---|---|---|
| C4 | 24.00 | 1033.00 | 43.04 | 407.70 | 16.99 | 2578.00 | 107.42 | 158.15 |
| C4 | 28.00 | 1038.00 | 37.07 | 390.00 | 13.93 | 1748.00 | 62.43 | 223.11 |
| C4 | 19.00 | 998.00 | 52.53 | 384.40 | 20.23 | 2234.00 | 117.58 | 172.07 |
| C4 | 24.00 | 781.00 | 32.54 | 312.50 | 13.02 | 1785.00 | 74.38 | 175.07 |
| C4 | 23.00 | 861.00 | 37.43 | 320.50 | 13.93 | 1843.00 | 80.13 | 173.90 |
| C4 | 24.00 | 986.00 | 41.08 | 398.00 | 16.58 | 2233.00 | 93.04 | 178.24 |
| C5 | 25.00 | 800.00 | 32.00 | 260.30 | 10.41 | 1725.00 | 69.00 | 150.90 |
| C5 | 14.00 | 539.00 | 38.50 | 182.20 | 13.01 | 1180.00 | 84.29 | 154.41 |
| C5 | 9.00 | 329.00 | 36.56 | 111.90 | 12.43 | 713.00 | 79.22 | 156.94 |
| C5 | 22.00 | 846.00 | 38.45 | 298.00 | 13.55 | 1876.00 | 85.27 | 158.85 |
| C5 | 20.00 | 1022.00 | 51.10 | 426.40 | 21.32 | 2215.00 | 110.75 | 192.51 |
| C5 | 24.00 | 816.00 | 34.00 | 329.90 | 13.75 | 1825.00 | 76.04 | 180.77 |
| C6 | 27.00 | 915.00 | 33.89 | 342.80 | 12.70 | 2003.00 | 74.19 | 171.14 |
| C6 | 17.00 | 869.00 | 51.12 | 261.50 | 15.38 | 1930.00 | 113.53 | 135.49 |
| C6 | 20.00 | 869.00 | 43.45 | 320.80 | 16.04 | 1935.00 | 96.75 | 165.79 |
| C6 | 18.00 | 521.00 | 28.94 | 182.40 | 10.13 | 1124.00 | 62.44 | 162.28 |
| C6 | 20.00 | 896.00 | 44.80 | 321.30 | 16.06 | 1973.00 | 98.65 | 162.85 |
| C6 | 23.00 | 1084.00 | 47.13 | 422.20 | 18.36 | 2434.00 | 105.83 | 173.46 |
| D1 | 18.00 | 802.00 | 44.56 | 303.90 | 16.88 | 1874.00 | 104.11 | 162.17 |
| D1 | 19.00 | 701.00 | 36.89 | 211.20 | 11.12 | 1330.00 | 70.00 | 158.80 |
| D1 | 19.00 | 841.00 | 44.26 | 279.70 | 14.72 | 1801.00 | 94.79 | 155.30 |
| D1 | 18.00 | 1016.00 | 56.44 | 393.50 | 21.86 | 2303.00 | 127.94 | 170.86 |
| D1 | 15.00 | 925.00 | 61.67 | 334.30 | 22.29 | 1984.00 | 132.27 | 168.50 |
| D1 | 26.00 | 815.00 | 31.35 | 329.70 | 12.68 | 1865.00 | 71.73 | 176.78 |
| D2 | 20.00 | 1128.00 | 56.40 | 465.40 | 23.27 | 2578.00 | 128.90 | 180.53 |
| D2 | 25.00 | 846.00 | 33.84 | 330.40 | 13.22 | 1886.00 | 75.44 | 175.19 |
| D2 | 23.00 | 722.00 | 31.39 | 222.60 | 9.68 | 1480.00 | 64.35 | 150.41 |
| D2 | 22.00 | 860.00 | 39.09 | 313.90 | 14.27 | 1909.00 | 86.77 | 164.43 |
| D2 | 21.00 | 835.00 | 39.76 | 232.50 | 11.07 | 1772.00 | 84.38 | 131.21 |
| D2 | 32.00 | 988.00 | 30.88 | 368.40 | 11.51 | 2211.00 | 69.09 | 166.62 |

continued ...

Table 6. Continued.

| Chamber | Pl/row | Pod/row | Pod/pl | Seedw/r | Seedw/pl | Seed/row | Seed/pl | Kseedw |
|---|---|---|---|---|---|---|---|---|
| D3 | 16.00 | 786.00 | 49.12 | 323.20 | 20.20 | 1786.00 | 111.63 | 180.96 |
| D3 | 23.00 | 1080.00 | 46.96 | 399.00 | 17.35 | 2291.00 | 99.61 | 174.16 |
| D3 | 20.00 | 633.00 | 31.65 | 201.60 | 10.08 | 1181.00 | 59.05 | 170.70 |
| D3 | 20.00 | 799.00 | 39.95 | 299.70 | 14.98 | 1767.00 | 88.35 | 169.61 |
| D3 | 25.00 | 994.00 | 39.76 | 396.20 | 15.85 | 2256.00 | 90.24 | 175.62 |
| D3 | 31.00 | 1097.00 | 35.39 | 429.40 | 13.85 | 2396.00 | 77.29 | 179.22 |
| D4 | 23.00 | 703.00 | 30.57 | 281.10 | 12.22 | 1572.00 | 68.35 | 178.82 |
| D4 | 20.00 | 756.00 | 37.80 | 265.20 | 13.26 | 1627.00 | 81.35 | 163.00 |
| D4 | 18.00 | 717.00 | 39.83 | 258.10 | 14.34 | 1448.00 | 80.44 | 178.25 |
| D4 | 26.00 | 800.00 | 30.77 | 344.70 | 13.26 | 1823.00 | 70.12 | 189.08 |
| D4 | 24.00 | 789.00 | 32.87 | 282.00 | 11.75 | 1646.00 | 68.58 | 171.32 |
| D4 | 22.00 | 901.00 | 40.95 | 351.40 | 15.97 | 1822.00 | 82.82 | 192.86 |
| D5 | 24.00 | 725.00 | 30.21 | 258.50 | 10.77 | 1560.00 | 65.00 | 165.71 |
| D5 | 28.00 | 813.00 | 29.04 | 277.10 | 9.90 | 1826.00 | 65.21 | 151.75 |
| D5 | 24.00 | 768.00 | 32.00 | 279.70 | 11.65 | 1706.00 | 71.08 | 163.95 |
| D5 | 20.00 | 892.00 | 44.60 | 352.90 | 17.64 | 2079.00 | 103.95 | 169.75 |
| D5 | 24.00 | 1070.00 | 44.58 | 385.50 | 16.06 | 1860.00 | 77.50 | 207.26 |
| D5 | 27.00 | 785.00 | 29.07 | 283.30 | 10.49 | 1749.00 | 64.78 | 161.98 |
| D6 | 22.00 | 849.00 | 38.59 | 363.80 | 16.54 | 1790.00 | 81.36 | 203.24 |
| D6 | 17.00 | 544.00 | 32.00 | 200.40 | 11.79 | 1211.00 | 71.24 | 165.48 |
| D6 | 17.00 | 356.00 | 20.94 | 127.30 | 7.49 | 775.00 | 45.59 | 164.26 |
| D6 | 15.00 | 666.00 | 44.40 | 277.60 | 18.51 | 1516.00 | 101.07 | 183.11 |
| D6 | 14.00 | 492.00 | 35.14 | 193.30 | 13.81 | 1074.00 | 76.71 | 179.98 |
| D6 | 22.00 | 653.00 | 29.68 | 264.70 | 12.03 | 1445.00 | 65.68 | 183.18 |
| E1 | 18.00 | 687.00 | 38.17 | 248.80 | 13.82 | 1400.00 | 77.78 | 177.71 |
| E1 | 19.00 | 840.00 | 44.21 | 303.40 | 15.97 | 1821.00 | 95.84 | 166.61 |
| E1 | 15.00 | 524.00 | 34.93 | 178.80 | 11.92 | 1117.00 | 74.47 | 160.07 |
| E1 | 18.00 | 923.00 | 51.28 | 340.90 | 18.94 | 2072.00 | 115.11 | 164.53 |
| E1 | 26.00 | 961.00 | 36.96 | 364.00 | 14.00 | 2100.00 | 80.77 | 173.33 |
| E1 | 21.00 | 702.00 | 33.43 | 267.00 | 12.71 | 1423.00 | 67.76 | 187.63 |

continued ...

Table 6. Concluded.

| Chamber | Pl/row | Pod/row | Pod/pl | Seedw/r | Seedw/pl | Seed/row | Seed/pl | Kseedw |
|---|---|---|---|---|---|---|---|---|
| E2 | 23.00 | 1302.00 | 56.61 | 499.80 | 21.73 | 2907.00 | 126.39 | 171.93 |
| E2 | 19.00 | 696.00 | 36.63 | 237.40 | 12.49 | 1491.00 | 78.47 | 159.22 |
| E2 | 21.00 | 795.00 | 37.86 | 286.10 | 13.62 | 1562.00 | 74.38 | 183.16 |
| E2 | 17.00 | 690.00 | 40.59 | 260.40 | 15.32 | 1540.00 | 90.59 | 169.09 |
| E2 | 7.00 | 186.00 | 26.57 | 69.60 | 9.94 | 436.00 | 62.29 | 159.63 |
| E2 | 12.00 | 921.00 | 76.75 | 378.20 | 31.52 | 2133.00 | 177.75 | 177.31 |
| E3 | 24.00 | 679.00 | 28.29 | 298.50 | 12.44 | 1626.00 | 67.75 | 183.58 |
| E3 | 23.00 | 882.00 | 38.35 | 341.70 | 14.86 | 1959.00 | 85.17 | 174.43 |
| E3 | 22.00 | 904.00 | 41.09 | 353.00 | 16.05 | 1993.00 | 90.59 | 177.12 |
| E3 | 23.00 | 532.00 | 23.13 | 213.90 | 9.30 | 1194.00 | 51.91 | 179.15 |
| E3 | 23.00 | 550.00 | 23.91 | 242.80 | 10.56 | 1283.00 | 55.78 | 189.24 |
| E3 | 27.00 | 723.00 | 26.78 | 307.50 | 11.39 | 1663.00 | 61.59 | 184.91 |
| E4 | 30.00 | 1144.00 | 38.13 | 411.40 | 13.71 | 2592.00 | 86.40 | 158.72 |
| E4 | 29.00 | 1085.00 | 37.41 | 361.20 | 12.46 | 2198.00 | 75.79 | 164.33 |
| E4 | 22.00 | 1078.00 | 49.00 | 383.80 | 17.45 | 2376.00 | 108.00 | 161.53 |
| E4 | 29.00 | 1179.00 | 40.66 | 424.90 | 14.65 | 2603.00 | 89.76 | 163.23 |
| E4 | 26.00 | 1144.00 | 44.00 | 439.90 | 16.9 | 2576.00 | 99.08 | 170.77 |
| E4 | 21.00 | 1296.00 | 61.71 | 510.00 | 24.29 | 2928.00 | 139.43 | 174.18 |
| E5 | 26.00 | 787.00 | 30.27 | 305.40 | 11.75 | 1729.00 | 66.50 | 176.63 |
| E5 | 26.00 | 742.00 | 28.54 | 289.80 | 11.15 | 1712.00 | 65.85 | 169.28 |
| E5 | 28.00 | 951.00 | 33.96 | 353.60 | 12.63 | 2104.00 | 75.14 | 168.06 |
| E5 | 25.00 | 1125.00 | 45.00 | 411.90 | 16.48 | 2296.00 | 91.84 | 179.40 |
| E5 | 23.00 | 1029.00 | 44.74 | 371.90 | 16.17 | 2231.00 | 97.00 | 166.70 |
| E5 | 21.00 | 936.00 | 44.57 | 354.70 | 16.89 | 2062.00 | 98.19 | 172.02 |
| E6 | 16.00 | 758.00 | 47.37 | 339.00 | 21.19 | 1721.00 | 107.56 | 196.98 |
| E6 | 22.00 | 1118.00 | 50.82 | 503.10 | 22.87 | 2561.00 | 116.41 | 196.45 |
| E6 | 15.00 | 737.00 | 49.13 | 255.40 | 17.03 | 1501.00 | 100.07 | 170.15 |
| E6 | 17.00 | 838.00 | 49.29 | 355.90 | 20.94 | 1773.00 | 104.29 | 200.73 |
| E6 | 16.00 | 710.00 | 44.38 | 250.50 | 15.66 | 1428.00 | 89.25 | 175.42 |
| E6 | 25.00 | 953.00 | 38.12 | 375.10 | 15.00 | 2104.00 | 84.16 | 178.28 |

[a]All weights expressed in grams. Kseedw = thousand seed weight.

## 6.3 SUMMARY OF FUMIGATION EPISODES

Table 7. Chamber A5-dispensed $SO_2$ data.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 1 | 175 | 112.8 | 52.6 |
| 2 | 182 | 121.2 | 38.8 |
| 3 | 183 | 1.0 | 1.0 |
| 4 | 185 | 26.3 | 26.3 |
| 5 | 189 | 40.1 | 17.7 |
| 6 | 190 | 1.7 | 1.7 |
| 7 | 191 | 116.6 | 53.4 |
| 8 | 193 | 76.9 | 22.8 |
| 9 | 194 | 26.1 | 8.3 |
| 10 | 195 | 18.2 | 10.1 |
| 11 | 196 | 57.2 | 29.7 |
| 12 | 204 | 835.0 | 222.5 |
| 13 | 212 | 61.9 | 32.1 |
| 14 | 215 | 2.2 | 1.0 |
| 15 | 216 | 2.2 | 0.9 |
| 16 | 217 | 50.3 | 23.9 |
| 17 | 220 | 280.6 | 70.6 |
| 18 | 221 | 74.4 | 5.1 |
| 19 | 222 | 90.5 | 4.9 |
| 20 | 223 | 80.5 | 4.0 |
| 21 | 224 | 89.8 | 4.5 |
| 22 | 225 | 44.9 | 4.7 |
| 23 | 226 | 50.0 | 26.3 |
| 24 | 228 | 14.1 | 3.3 |
| 25 | 229 | 5.0 | 1.5 |
| 26 | 231 | 84.4 | 32.8 |
| 27 | 232 | 5.2 | 2.2 |
| 28 | 235 | 6.5 | 6.5 |
| 29 | 239 | 4.6 | 4.6 |
| 30 | 241 | 225.9 | 60.9 |
| 31 | 242 | 16.4 | 16.4 |
| | | 2622.5 | 222.5 |
| Cummulative numerical integral and highest peak (ppb) respectively | | | |

* This integral is obtained by numerical integration of the pollutant concentration with respect to time over the episode duration.

Table 8. Chamber A6-dispensed $SO_2$ data.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 1 | 170 | 9.4 | 9.4 |
| 2 | 175 | 34.5 | 22.6 |
| 3 | 178 | 3.3 | 3.3 |
| 4 | 182 | 169.4 | 54.3 |
| 5 | 183 | 14.2 | 12.8 |
| 6 | 189 | 23.8 | 10.5 |
| 7 | 190 | 2.1 | 2.0 |
| 8 | 191 | 111.3 | 51.3 |
| 9 | 193 | 79.9 | 23.4 |
| 10 | 194 | 30.2 | 8.7 |
| 11 | 195 | 14.9 | 7.1 |
| 12 | 196 | 52.7 | 29.5 |
| 13 | 204 | 989.0 | 257.2 |
| 14 | 212 | 59.7 | 34.5 |
| 15 | 215 | 7.9 | 2.0 |
| 16 | 216 | 21.9 | 4.0 |
| 17 | 217 | 53.6 | 23.6 |
| 18 | 220 | 281.0 | 70.6 |
| 19 | 221 | 77.1 | 4.8 |
| 20 | 222 | 94.6 | 5.1 |
| 21 | 223 | 85.3 | 4.2 |
| 22 | 224 | 93.3 | 4.9 |
| 23 | 225 | 47.8 | 5.4 |
| 24 | 226 | 54.4 | 27.3 |
| 25 | 228 | 22.2 | 5.1 |
| 26 | 229 | 11.7 | 2.4 |
| 27 | 230 | 2.4 | 0.7 |
| 28 | 231 | 114.3 | 34.6 |
| 29 | 232 | 8.5 | 4.0 |
| 30 | 235 | 1.5 | 1.5 |
| 31 | 241 | 217.1 | 56.4 |
| 32 | 242 | 1.1 | 1.1 |
| | | 2790.1 | 257.2 |
| Cummulative numerical integral and highest peak (ppb) respectively | | | |

* This integral is obtained by numerical integration of the pollutant concentration with respect to time over the episode duration.

Table 9. Chamber C2-dispensed $SO_2$ data.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 1 | 175 | 117.2 | 56.5 |
| 2 | 182 | 97.4 | 31.2 |
| 3 | 190 | 8.1 | 5.7 |
| 4 | 191 | 109.2 | 51.4 |
| 5 | 193 | 15.5 | 7.8 |
| 6 | 195 | 10.3 | 10.3 |
| 7 | 196 | 192.9 | 40.0 |
| 8 | 197 | 9.2 | 2.7 |
| 9 | 199 | 1.9 | 0.8 |
| 10 | 200 | 1.3 | 0.3 |
| 11 | 201 | 1.6 | 0.5 |
| 12 | 204 | 655.8 | 219.8 |
| 13 | 212 | 57.2 | 32.1 |
| 14 | 217 | 53.9 | 25.8 |
| 15 | 220 | 322.0 | 82.2 |
| 16 | 226 | 30.2 | 23.5 |
| 17 | 231 | 43.2 | 25.5 |
| 18 | 239 | 6.7 | 6.7 |
| 19 | 241 | 217.9 | 64.6 |
| 20 | 242 | 8.9 | 8.9 |
| | | 1960.4 | 219.8 |
| Cummulative numerical integral and highest peak (ppb) respectively | | | |

* This integral is obtained by numerical integration of the pollutant concentration with respect to time over the episode duration.

Table 10. Chamber C3-dispensed $SO_2$ data.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 1 | 175 | 116.4 | 56.0 |
| 2 | 182 | 113.6 | 32.9 |
| 3 | 183 | 13.1 | 12.1 |
| 4 | 189 | 24.9 | 11.2 |
| 5 | 190 | 1.3 | 1.3 |
| 6 | 191 | 105.6 | 49.3 |
| 7 | 193 | 72.3 | 21.7 |
| 8 | 194 | 27.3 | 8.1 |
| 9 | 195 | 11.9 | 6.0 |
| 10 | 196 | 51.7 | 30.3 |
| 11 | 204 | 859.2 | 255.0 |
| 12 | 212 | 68.5 | 36.9 |
| 13 | 215 | 4.2 | 1.0 |
| 14 | 216 | 9.6 | 2.5 |
| 15 | 217 | 50.6 | 23.6 |
| 16 | 220 | 283.4 | 70.9 |
| 17 | 221 | 79.6 | 5.3 |
| 18 | 222 | 94.7 | 4.9 |
| 19 | 223 | 85.9 | 4.1 |
| 20 | 224 | 96.5 | 4.6 |
| 21 | 225 | 47.0 | 5.1 |
| 22 | 226 | 46.1 | 26.7 |
| 23 | 228 | 21.1 | 4.0 |
| 24 | 229 | 13.0 | 3.2 |
| 25 | 230 | 1.1 | 0.5 |
| 26 | 231 | 86.3 | 27.9 |
| 27 | 232 | 6.2 | 2.9 |
| 28 | 235 | 2.8 | 2.8 |
| 29 | 239 | 9.2 | 9.2 |
| 30 | 241 | 214.5 | 58.9 |
| 31 | 242 | 8.9 | 8.9 |
| | | 2626.5 | 255.0 |
| Cummulative numerical integral and highest peak (ppb) respectively | | | |

* This integral is obtained by numerical integration of the pollutant concentration with respect to time over the episode duration.

Table 11. Chamber D6-dispensed $SO_2$ data.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 1 | 175 | 26.7 | 18.4 |
| 2 | 182 | 138.9 | 53.2 |
| 3 | 183 | 22.3 | 21.9 |
| 4 | 189 | 25.1 | 10.4 |
| 5 | 190 | 1.9 | 1.9 |
| 6 | 191 | 108.5 | 51.5 |
| 7 | 193 | 78.7 | 22.9 |
| 8 | 194 | 27.6 | 8.8 |
| 9 | 195 | 14.7 | 7.3 |
| 10 | 196 | 48.8 | 27.9 |
| 11 | 204 | 880.0 | 221.9 |
| 12 | 212 | 52.1 | 28.6 |
| 13 | 215 | 2.7 | 1.2 |
| 14 | 216 | 9.5 | 2.8 |
| 15 | 217 | 49.3 | 24.1 |
| 16 | 220 | 269.3 | 67.8 |
| 17 | 221 | 75.5 | 4.9 |
| 18 | 222 | 98.6 | 5.1 |
| 19 | 223 | 89.3 | 4.7 |
| 20 | 224 | 95.2 | 5.3 |
| 21 | 225 | 49.8 | 5.3 |
| 22 | 226 | 47.4 | 27.1 |
| 23 | 228 | 18.1 | 3.9 |
| 24 | 229 | 4.6 | 1.1 |
| 25 | 231 | 108.3 | 31.1 |
| 26 | 232 | 6.8 | 3.2 |
| 27 | 235 | 7.5 | 7.5 |
| 28 | 239 | 5.2 | 5.2 |
| 29 | 241 | 228.4 | 63.2 |
| 30 | 242 | 27.8 | 27.8 |
| 31 | 254 | 375.1 | 375.1 |
| Cummulative numerical integral and highest peak (ppb) respectively | | 2993.7 | 221.9 |

* This integral is obtained by numerical integration of the pollutant concentration with respect to time over the episode duration.

Table 12. Chamber El-dispensed $SO_2$ data.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 1 | 175 | 107.0 | 52.2 |
| 2 | 182 | 119.4 | 46.9 |
| 3 | 189 | 19.9 | 19.5 |
| 4 | 190 | 9.5 | 6.9 |
| 5 | 191 | 104.4 | 51.2 |
| 6 | 193 | 15.5 | 7.3 |
| 7 | 195 | 4.9 | 4.9 |
| 8 | 196 | 173.9 | 27.9 |
| 9 | 197 | 8.7 | 2.8 |
| 10 | 199 | 1.9 | 0.8 |
| 11 | 201 | 1.2 | 0.4 |
| 12 | 204 | 688.9 | 232.8 |
| 13 | 212 | 64.3 | 35.6 |
| 14 | 216 | 1.7 | 0.9 |
| 15 | 217 | 42.5 | 22.1 |
| 16 | 220 | 320.9 | 80.8 |
| 17 | 226 | 25.3 | 19.4 |
| 18 | 231 | 46.9 | 26.9 |
| 19 | 239 | 5.5 | 5.5 |
| 20 | 241 | 212.9 | 56.1 |
| 21 | 242 | 19.2 | 19.2 |
| | | 1994.4 | 232.8 |
| Cummulative numerical integral and highest peak (ppb) respectively | | | |

* This integral is obtained by numerical integration of the pollutant concentration with respect to time over the episode duration.

Table 13. Chamber B1-dispensed $O_3$ data.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 1 | 170 | 242.7 | 35.6 |
| 2 | 171 | 665.1 | 51.1 |
| 3 | 172 | 846.5 | 67.4 |
| 4 | 173 | 1183.3 | 71.0 |
| 5 | 174 | 862.7 | 83.0 |
| 6 | 175 | 449.0 | 74.9 |
| 7 | 177 | 735.8 | 90.1 |
| 8 | 178 | 795.1 | 49.1 |
| 9 | 179 | 576.8 | 57.2 |
| 10 | 180 | 847.6 | 49.7 |
| 11 | 181 | 799.1 | 38.9 |
| 12 | 182 | 815.7 | 65.3 |
| 13 | 183 | 829.7 | 52.0 |
| 14 | 184 | 657.2 | 65.7 |
| 15 | 185 | 1054.8 | 80.2 |
| 16 | 186 | 1298.9 | 66.6 |
| 17 | 187 | 1049.6 | 60.5 |
| 18 | 188 | 970.0 | 72.5 |
| 19 | 189 | 1092.8 | 80.6 |
| 20 | 190 | 1517.2 | 391.0 |
| 21 | 191 | 1078.2 | 108.5 |
| 22 | 192 | 906.8 | 76.4 |
| 23 | 193 | 1139.5 | 107.9 |
| 24 | 194 | 739.9 | 62.9 |
| 25 | 195 | 1144.1 | 72.9 |
| 26 | 196 | 1182.4 | 103.8 |
| 27 | 197 | 1052.0 | 106.5 |
| 28 | 198 | 845.3 | 61.6 |
| 29 | 199 | 1114.1 | 74.1 |
| 30 | 200 | 910.0 | 68.0 |
| 31 | 201 | 758.3 | 63.5 |
| 32 | 203 | 384.6 | 56.1 |
| 33 | 204 | 692.7 | 55.8 |
| 34 | 205 | 902.1 | 67.6 |
| 35 | 206 | 1325.9 | 97.1 |
| 36 | 207 | 592.3 | 46.9 |
| 37 | 208 | 737.6 | 56.5 |
| 38 | 209 | 924.5 | 72.2 |
| 39 | 210 | 1163.0 | 75.5 |
| 40 | 211 | 1157.2 | 134.2 |
| 41 | 212 | 1341.1 | 97.6 |
| 42 | 213 | 947.5 | 55.4 |
| 43 | 214 | 979.5 | 65.4 |
| 44 | 215 | 934.9 | 65.0 |
| 45 | 216 | 815.1 | 74.1 |
| 46 | 217 | 1093.3 | 56.9 |
| 47 | 218 | 900.8 | 52.4 |
| 48 | 219 | 1070.1 | 102.2 |
| 49 | 220 | 618.2 | 69.3 |
| 50 | 221 | 533.8 | 40.2 |
| 51 | 222 | 415.6 | 28.9 |
| 52 | 223 | 484.4 | 36.6 |
| 53 | 224 | 469.1 | 29.0 |
| 54 | 225 | 430.8 | 37.1 |
| 55 | 226 | 569.2 | 40.1 |
| 56 | 227 | 424.6 | 39.0 |
| 57 | 228 | 456.4 | 32.2 |
| 58 | 229 | 444.5 | 33.5 |
| 59 | 230 | 332.9 | 18.5 |
| 60 | 231 | 485.3 | 42.5 |

continued ...

Table 13. Concluded.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 61 | 232 | 891.7 | 73.5 |
| 62 | 233 | 580.1 | 32.6 |
| 63 | 234 | 437.1 | 33.4 |
| 64 | 235 | 404.1 | 41.1 |
| 65 | 236 | 457.9 | 37.0 |
| 66 | 239 | 225.2 | 21.3 |
| 67 | 240 | 501.7 | 34.0 |
| 68 | 241 | 493.1 | 35.8 |
| 69 | 242 | 753.4 | 59.8 |
| 70 | 243 | 544.0 | 45.5 |
| 71 | 244 | 301.1 | 23.4 |
| 72 | 245 | 417.9 | 32.8 |
| 73 | 246 | 460.1 | 34.6 |
| 74 | 247 | 661.7 | 40.7 |
| 75 | 248 | 528.2 | 27.6 |
| 76 | 249 | 353.8 | 36.9 |
| 77 | 250 | 527.5 | 51.7 |
| 78 | 251 | 523.9 | 53.9 |
| 79 | 252 | 618.2 | 43.3 |
| 80 | 253 | 470.8 | 29.2 |
| 81 | 254 | 405.9 | 37.6 |
| 82 | 255 | 504.9 | 34.5 |
| 83 | 256 | 590.9 | 35.4 |
| 84 | 257 | 200.5 | 12.5 |
| 85 | 258 | 352.3 | 24.4 |
| 86 | 259 | 491.3 | 33.3 |
| 87 | 260 | 482.4 | 27.0 |
| 88 | 261 | 338.8 | 27.4 |
| 89 | 262 | 422.2 | 27.9 |
| 90 | 263 | 454.1 | 32.7 |
| 91 | 264 | 193.3 | 14.4 |
| 92 | 265 | 143.7 | 16.6 |
| | | 64519.0 | 391.0 |
| Cummulative numerical integral and highest peak (ppb) respectively | | | |

* This integral is obtained by numerical integration of the pollutant concentration with respect to time over the episode duration.

Table 14. Chamber C4-dispensed $O_3$ data.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 1 | 170 | 226.6 | 33.6 |
| 2 | 171 | 642.5 | 49.4 |
| 3 | 172 | 808.3 | 64.5 |
| 4 | 173 | 1130.9 | 68.8 |
| 5 | 174 | 801.3 | 78.4 |
| 6 | 175 | 410.8 | 71.7 |
| 7 | 177 | 702.3 | 84.8 |
| 8 | 178 | 771.8 | 46.6 |
| 9 | 179 | 547.1 | 54.5 |
| 10 | 180 | 806.0 | 48.8 |
| 11 | 181 | 795.0 | 38.0 |
| 12 | 182 | 788.2 | 63.3 |
| 13 | 183 | 769.9 | 50.7 |
| 14 | 184 | 642.0 | 63.1 |
| 15 | 185 | 1039.4 | 75.9 |
| 16 | 186 | 1230.1 | 63.0 |
| 17 | 187 | 995.0 | 57.7 |
| 18 | 188 | 914.1 | 70.5 |
| 19 | 189 | 1024.8 | 76.2 |
| 20 | 190 | 1490.1 | 395.8 |
| 21 | 191 | 1049.7 | 102.9 |
| 22 | 192 | 872.6 | 73.2 |
| 23 | 193 | 1121.7 | 105.6 |
| 24 | 194 | 733.2 | 62.7 |
| 25 | 195 | 1098.7 | 70.0 |
| 26 | 196 | 1125.2 | 99.1 |
| 27 | 197 | 1021.8 | 100.5 |
| 28 | 198 | 855.3 | 60.4 |
| 29 | 199 | 1081.3 | 70.8 |
| 30 | 200 | 906.5 | 66.1 |
| 31 | 201 | 729.3 | 60.6 |
| 32 | 203 | 387.0 | 53.9 |
| 33 | 204 | 721.2 | 56.8 |
| 34 | 205 | 871.4 | 65.9 |
| 35 | 206 | 1261.3 | 92.1 |
| 36 | 207 | 589.0 | 48.3 |
| 37 | 208 | 726.8 | 55.5 |
| 38 | 209 | 880.8 | 69.5 |
| 39 | 210 | 1126.8 | 70.3 |
| 40 | 211 | 1119.3 | 130.5 |
| 41 | 212 | 1288.4 | 89.6 |
| 42 | 213 | 934.6 | 62.8 |
| 43 | 214 | 940.7 | 62.7 |
| 44 | 215 | 913.6 | 61.7 |
| 45 | 216 | 805.9 | 69.9 |
| 46 | 217 | 1055.4 | 55.4 |
| 47 | 218 | 886.2 | 51.4 |
| 48 | 219 | 1046.3 | 98.9 |
| 49 | 220 | 600.4 | 66.7 |
| 50 | 221 | 534.1 | 39.5 |
| 51 | 222 | 420.1 | 29.6 |
| 52 | 223 | 472.9 | 34.5 |
| 53 | 224 | 477.5 | 30.9 |
| 54 | 225 | 411.9 | 36.2 |
| 55 | 226 | 567.7 | 39.8 |
| 56 | 227 | 443.0 | 38.0 |
| 57 | 228 | 456.9 | 31.3 |
| 58 | 229 | 423.1 | 25.7 |
| 59 | 230 | 311.1 | 18.3 |
| 60 | 231 | 468.0 | 41.1 |

continued ...

Table 14. Concluded.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 61 | 232 | 851.8 | 70.8 |
| 62 | 233 | 556.4 | 31.8 |
| 63 | 234 | 429.4 | 32.3 |
| 64 | 235 | 399.0 | 39.8 |
| 65 | 236 | 442.8 | 35.7 |
| 66 | 239 | 232.5 | 21.3 |
| 67 | 240 | 496.7 | 33.4 |
| 68 | 241 | 484.5 | 34.8 |
| 69 | 242 | 714.8 | 57.2 |
| 70 | 243 | 517.7 | 43.5 |
| 71 | 244 | 293.9 | 21.6 |
| 72 | 245 | 397.7 | 31.2 |
| 73 | 246 | 438.2 | 32.9 |
| 74 | 247 | 626.3 | 38.5 |
| 75 | 248 | 507.2 | 26.6 |
| 76 | 249 | 336.0 | 34.8 |
| 77 | 250 | 509.8 | 50.0 |
| 78 | 251 | 498.6 | 52.4 |
| 79 | 252 | 588.7 | 41.7 |
| 80 | 253 | 453.2 | 27.9 |
| 81 | 254 | 392.0 | 36.0 |
| 82 | 255 | 483.9 | 33.3 |
| 83 | 256 | 562.6 | 34.4 |
| 84 | 257 | 192.7 | 12.1 |
| 85 | 258 | 339.9 | 23.2 |
| 86 | 259 | 475.5 | 32.1 |
| 87 | 260 | 466.7 | 25.9 |
| 88 | 261 | 328.4 | 26.6 |
| 89 | 262 | 409.2 | 27.0 |
| 90 | 263 | 437.4 | 31.1 |
| 91 | 264 | 182.6 | 13.4 |
| 92 | 265 | 134.5 | 15.9 |
| | | 62453.5 | 395.8 |
| Cummulative numerical integral and highest peak (ppb) respectively | | | |

* This integral is obtained by numerical integration of the pollutant concentration with respect to time over the episode duration.

Table 15. Chamber D3-dispensed $O_3$ data.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 1 | 175 | 27.2 | 27.2 |
| 2 | 184 | 553.7 | 59.7 |
| 3 | 185 | 998.1 | 58.1 |
| 4 | 186 | 613.6 | 38.5 |
| 5 | 187 | 251.1 | 37.7 |
| 6 | 188 | 208.9 | 25.7 |
| 7 | 189 | 735.5 | 61.6 |
| 8 | 190 | 1078.0 | 322.4 |
| 9 | 191 | 686.0 | 64.5 |
| 10 | 192 | 691.5 | 60.9 |
| 11 | 193 | 754.6 | 65.2 |
| 12 | 194 | 659.5 | 37.3 |
| 13 | 195 | 755.3 | 49.7 |
| 14 | 196 | 800.8 | 65.6 |
| 15 | 197 | 1203.1 | 131.1 |
| 16 | 198 | 1227.9 | 79.4 |
| 17 | 199 | 1062.0 | 63.9 |
| 18 | 200 | 1111.2 | 68.4 |
| 19 | 201 | 849.9 | 58.5 |
| 20 | 203 | 518.7 | 62.8 |
| 21 | 204 | 1373.7 | 87.8 |
| 22 | 205 | 1065.3 | 58.3 |
| 23 | 206 | 850.9 | 61.3 |
| 24 | 207 | 807.6 | 73.8 |
| 25 | 208 | 922.9 | 57.9 |
| 26 | 209 | 705.1 | 44.9 |
| 27 | 210 | 940.8 | 62.9 |
| 28 | 211 | 985.2 | 60.5 |
| 29 | 212 | 895.4 | 61.0 |
| 30 | 213 | 1019.0 | 58.0 |
| 31 | 214 | 1039.8 | 59.5 |
| 32 | 215 | 1029.6 | 56.9 |
| 33 | 216 | 989.6 | 61.3 |
| 34 | 217 | 996.7 | 59.4 |
| 35 | 218 | 943.4 | 57.4 |
| 36 | 219 | 769.5 | 74.2 |
| 37 | 220 | 651.2 | 57.8 |
| 38 | 221 | 748.1 | 59.5 |
| 39 | 222 | 1032.2 | 58.9 |
| 40 | 223 | 1032.5 | 57.7 |
| 41 | 224 | 1014.4 | 73.0 |
| 42 | 225 | 1033.4 | 73.7 |
| 43 | 226 | 1050.3 | 57.8 |
| 44 | 227 | 1178.9 | 74.9 |
| 45 | 228 | 1068.7 | 58.3 |
| 46 | 229 | 389.9 | 37.2 |
| 47 | 230 | 158.2 | 11.1 |
| 48 | 231 | 637.7 | 60.2 |
| 49 | 232 | 738.3 | 59.5 |
| 50 | 233 | 934.6 | 63.3 |
| 51 | 234 | 618.5 | 59.4 |
| 52 | 235 | 666.7 | 57.6 |
| 53 | 236 | 503.2 | 51.6 |
| 54 | 239 | 653.0 | 59.1 |
| 55 | 240 | 1029.4 | 60.5 |
| 56 | 241 | 1276.9 | 80.8 |
| 57 | 242 | 588.5 | 42.9 |
| 58 | 243 | 89.6 | 18.3 |
| 59 | 244 | 33.1 | 7.4 |
| 60 | 245 | 68.6 | 5.7 |

continued ...

Table 15. Concluded.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 61 | 246 | 48.8 | 6.7 |
| 62 | 247 | 220.5 | 22.2 |
| 63 | 248 | 189.2 | 16.9 |
| 64 | 249 | 32.7 | 5.1 |
| 65 | 250 | 156.5 | 23.7 |
| 66 | 251 | 34.8 | 3.7 |
| 67 | 252 | 150.7 | 18.2 |
| 68 | 253 | 129.9 | 12.6 |
| 69 | 254 | 97.6 | 15.4 |
| 70 | 255 | 165.2 | 18.9 |
| 71 | 256 | 284.5 | 22.2 |
| 72 | 257 | 58.4 | 4.6 |
| 73 | 258 | 55.4 | 5.7 |
| 74 | 259 | 166.5 | 17.5 |
| 75 | 260 | 136.1 | 9.0 |
| 76 | 261 | 103.4 | 13.5 |
| 77 | 262 | 87.2 | 13.3 |
| 78 | 263 | 126.2 | 12.9 |
| 79 | 264 | 21.3 | 2.2 |
| 80 | 265 | 16.4 | 2.4 |
| | | 49598.3 | 322.4 |
| Cummulative numerical integral and highest peak (ppb) respectively | | | |

* This integral is obtained by numerical integration of the pollutant concentration with respect to time over the episode duration.

Table 16. Chamber D4-dispensed $O_3$ data.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 1 | 170 | 442.9 | 72.2 |
| 2 | 171 | 807.8 | 73.1 |
| 3 | 172 | 1252.6 | 73.6 |
| 4 | 173 | 694.3 | 42.6 |
| 5 | 174 | 527.3 | 49.7 |
| 6 | 175 | 349.8 | 83.9 |
| 7 | 177 | 631.9 | 75.8 |
| 8 | 178 | 909.9 | 75.9 |
| 9 | 179 | 496.0 | 62.7 |
| 10 | 180 | 714.0 | 58.1 |
| 11 | 181 | 536.1 | 27.0 |
| 12 | 182 | 549.6 | 130.2 |
| 13 | 183 | 669.3 | 73.8 |
| 14 | 184 | 713.9 | 59.3 |
| 15 | 185 | 915.3 | 57.7 |
| 16 | 186 | 588.7 | 30.0 |
| 17 | 187 | 503.7 | 37.7 |
| 18 | 188 | 411.9 | 40.9 |
| 19 | 189 | 633.4 | 58.9 |
| 20 | 190 | 1236.3 | 375.7 |
| 21 | 191 | 633.8 | 61.8 |
| 22 | 192 | 689.1 | 58.7 |
| 23 | 193 | 644.9 | 64.1 |
| 24 | 194 | 323.8 | 25.2 |
| 25 | 195 | 460.1 | 42.7 |
| 26 | 196 | 583.9 | 62.3 |
| 27 | 197 | 1104.3 | 128.0 |
| 28 | 198 | 1220.1 | 78.0 |
| 29 | 199 | 1060.6 | 63.6 |
| 30 | 200 | 1114.1 | 68.8 |
| 31 | 201 | 837.3 | 57.9 |
| 32 | 203 | 525.4 | 59.8 |
| 33 | 204 | 1336.7 | 81.8 |
| 34 | 205 | 896.2 | 58.7 |
| 35 | 206 | 701.3 | 63.9 |
| 36 | 207 | 810.0 | 71.2 |
| 37 | 208 | 1025.8 | 58.2 |
| 38 | 209 | 942.5 | 57.9 |
| 39 | 210 | 838.7 | 58.8 |
| 40 | 211 | 990.8 | 58.9 |
| 41 | 212 | 854.4 | 61.4 |
| 42 | 213 | 1027.3 | 58.1 |
| 43 | 214 | 1034.3 | 58.1 |
| 44 | 215 | 1019.6 | 57.3 |
| 45 | 216 | 992.1 | 60.0 |
| 46 | 217 | 943.0 | 58.4 |
| 47 | 218 | 1021.9 | 59.5 |
| 48 | 219 | 958.0 | 71.9 |
| 49 | 220 | 650.8 | 58.3 |
| 50 | 221 | 747.8 | 58.0 |
| 51 | 222 | 1022.2 | 58.8 |
| 52 | 223 | 1025.1 | 58.7 |
| 53 | 224 | 998.1 | 74.2 |
| 54 | 225 | 1045.2 | 75.6 |
| 55 | 226 | 1040.4 | 57.5 |
| 56 | 227 | 1180.2 | 74.2 |
| 57 | 228 | 1059.9 | 57.7 |
| 58 | 229 | 387.6 | 37.6 |
| 59 | 230 | 143.7 | 9.2 |
| 60 | 231 | 641.6 | 59.3 |

continued ...

Table 16. Concluded.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 61 | 232 | 773.9 | 59.2 |
| 62 | 233 | 935.4 | 60.6 |
| 63 | 234 | 627.9 | 57.0 |
| 64 | 235 | 650.6 | 59.1 |
| 65 | 236 | 455.4 | 49.4 |
| 66 | 239 | 654.4 | 58.4 |
| 67 | 240 | 1027.1 | 59.3 |
| 68 | 241 | 1290.4 | 82.6 |
| 69 | 242 | 622.7 | 42.3 |
| 70 | 243 | 140.5 | 16.6 |
| 71 | 244 | 82.0 | 10.5 |
| 72 | 245 | 115.3 | 9.4 |
| 73 | 246 | 107.7 | 10.8 |
| 74 | 247 | 290.6 | 25.1 |
| 75 | 248 | 232.3 | 20.0 |
| 76 | 249 | 74.3 | 7.6 |
| 77 | 250 | 218.1 | 25.8 |
| 78 | 251 | 114.6 | 13.8 |
| 79 | 252 | 248.5 | 22.8 |
| 80 | 253 | 185.1 | 15.4 |
| 81 | 254 | 133.3 | 17.8 |
| 82 | 255 | 211.2 | 21.5 |
| 83 | 256 | 341.2 | 25.3 |
| 84 | 257 | 84.5 | 5.6 |
| 85 | 258 | 104.3 | 7.9 |
| 86 | 259 | 205.4 | 18.0 |
| 87 | 260 | 183.6 | 11.0 |
| 88 | 261 | 133.4 | 16.2 |
| 89 | 262 | 141.8 | 15.2 |
| 90 | 263 | 172.3 | 15.1 |
| 91 | 264 | 52.3 | 4.4 |
| 92 | 265 | 33.8 | 3.4 |
| | | 58761.2 | 375.7 |
| Cummulative numerical integral and highest peak (ppb) respectively | | | |

* This integral is obtained by numerical integration of the pollutant concentration with respect to time over the episode duration.

Table 17. Chamber E3-dispensed $O_3$ data.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 1 | 175 | 9.0 | 9.0 |
| 2 | 184 | 567.7 | 62.3 |
| 3 | 185 | 981.1 | 57.5 |
| 4 | 186 | 627.8 | 39.9 |
| 5 | 187 | 249.6 | 37.6 |
| 6 | 188 | 213.3 | 25.1 |
| 7 | 189 | 742.9 | 65.1 |
| 8 | 190 | 1065.1 | 321.1 |
| 9 | 191 | 669.0 | 62.6 |
| 10 | 192 | 691.6 | 59.5 |
| 11 | 193 | 781.6 | 61.4 |
| 12 | 194 | 692.3 | 41.4 |
| 13 | 195 | 788.4 | 51.7 |
| 14 | 196 | 810.6 | 65.6 |
| 15 | 197 | 1190.8 | 129.6 |
| 16 | 198 | 1219.8 | 77.1 |
| 17 | 199 | 1070.2 | 64.3 |
| 18 | 200 | 1112.8 | 68.3 |
| 19 | 201 | 640.2 | 56.4 |
| 20 | 203 | 452.7 | 67.8 |
| 21 | 204 | 1275.7 | 86.3 |
| 22 | 205 | 1059.0 | 59.7 |
| 23 | 206 | 831.7 | 65.0 |
| 24 | 207 | 836.2 | 77.6 |
| 25 | 208 | 969.1 | 57.7 |
| 26 | 209 | 692.9 | 40.6 |
| 27 | 210 | 943.7 | 62.6 |
| 28 | 211 | 1029.7 | 59.2 |
| 29 | 212 | 1008.2 | 63.4 |
| 30 | 213 | 1030.8 | 58.3 |
| 31 | 214 | 1034.4 | 58.5 |
| 32 | 215 | 1020.8 | 57.6 |
| 33 | 216 | 1025.9 | 59.5 |
| 34 | 217 | 1019.1 | 59.0 |
| 35 | 218 | 1026.6 | 59.4 |
| 36 | 219 | 826.7 | 64.4 |
| 37 | 220 | 640.4 | 56.7 |
| 38 | 221 | 767.5 | 59.1 |
| 39 | 222 | 1025.2 | 58.3 |
| 40 | 223 | 1034.8 | 59.0 |
| 41 | 224 | 992.3 | 75.8 |
| 42 | 225 | 1026.7 | 75.6 |
| 43 | 226 | 1058.6 | 60.2 |
| 44 | 227 | 1179.3 | 75.8 |
| 45 | 228 | 1071.4 | 60.6 |
| 46 | 229 | 384.9 | 36.4 |
| 47 | 230 | 153.1 | 10.6 |
| 48 | 231 | 629.4 | 60.2 |
| 49 | 232 | 747.8 | 57.9 |
| 50 | 233 | 937.5 | 57.8 |
| 51 | 234 | 616.2 | 59.6 |
| 52 | 235 | 694.7 | 58.3 |
| 53 | 236 | 502.6 | 50.0 |
| 54 | 239 | 646.8 | 57.9 |
| 55 | 240 | 1032.1 | 59.7 |
| 56 | 241 | 1291.1 | 81.2 |
| 57 | 242 | 569.5 | 41.3 |
| 58 | 243 | 102.2 | 16.0 |
| 59 | 244 | 42.6 | 7.3 |
| 60 | 245 | 73.8 | 6.5 |

continued ...

Table 17. Concluded.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 61 | 246 | 57.5 | 7.2 |
| 62 | 247 | 220.4 | 22.2 |
| 63 | 248 | 198.6 | 19.3 |
| 64 | 249 | 41.6 | 5.9 |
| 65 | 250 | 160.8 | 23.4 |
| 66 | 251 | 45.6 | 4.5 |
| 67 | 252 | 177.1 | 19.0 |
| 68 | 253 | 152.3 | 14.1 |
| 69 | 254 | 124.3 | 17.8 |
| 70 | 255 | 174.7 | 20.4 |
| 71 | 256 | 304.6 | 22.7 |
| 72 | 257 | 68.6 | 5.1 |
| 73 | 258 | 68.4 | 6.9 |
| 74 | 259 | 173.4 | 16.5 |
| 75 | 260 | 165.7 | 10.0 |
| 76 | 261 | 114.4 | 13.9 |
| 77 | 262 | 115.5 | 13.6 |
| 78 | 263 | 136.0 | 14.2 |
| 79 | 264 | 29.5 | 3.0 |
| 80 | 265 | 21.5 | 2.9 |
| | | 49978.2 | 321.1 |
| Cummulative numerical integral and highest peak (ppb) respectively | | | |

* This integral is obtained by numerical integration of the pollutant concentration with respect to time over the episode duration.

Table 18. Chamber E5-dispensed $O_3$ data.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 1 | 170 | 701.9 | 119.9 |
| 2 | 171 | 1624.4 | 181.5 |
| 3 | 172 | 386.5 | 32.4 |
| 4 | 173 | 612.0 | 44.2 |
| 5 | 174 | 394.3 | 33.6 |
| 6 | 175 | 171.0 | 30.8 |
| 7 | 177 | 388.6 | 51.0 |
| 8 | 178 | 413.3 | 26.4 |
| 9 | 179 | 373.5 | 42.7 |
| 10 | 180 | 610.3 | 48.9 |
| 11 | 181 | 689.1 | 34.6 |
| 12 | 182 | 344.1 | 25.4 |
| 13 | 183 | 433.5 | 37.7 |
| 14 | 184 | 311.1 | 30.9 |
| 15 | 185 | 518.6 | 38.6 |
| 16 | 186 | 747.8 | 43.2 |
| 17 | 187 | 642.4 | 38.9 |
| 18 | 188 | 399.4 | 38.5 |
| 19 | 189 | 397.0 | 34.6 |
| 20 | 190 | 1051.0 | 377.2 |
| 21 | 191 | 525.6 | 57.4 |
| 22 | 192 | 426.3 | 46.7 |
| 23 | 193 | 447.0 | 33.1 |
| 24 | 194 | 336.7 | 31.1 |
| 25 | 195 | 407.2 | 37.4 |
| 26 | 196 | 365.2 | 32.6 |
| 27 | 197 | 371.7 | 45.2 |
| 28 | 198 | 590.9 | 41.9 |
| 29 | 199 | 541.2 | 33.5 |
| 30 | 200 | 616.4 | 46.8 |
| 31 | 201 | 500.4 | 72.0 |
| 32 | 203 | 282.6 | 66.7 |
| 33 | 204 | 425.7 | 29.1 |
| 34 | 205 | 466.4 | 33.1 |
| 35 | 206 | 702.4 | 46.6 |
| 36 | 207 | 414.9 | 30.0 |
| 37 | 208 | 504.2 | 38.0 |
| 38 | 209 | 512.9 | 39.5 |
| 39 | 210 | 643.3 | 39.3 |
| 40 | 211 | 585.4 | 57.4 |
| 41 | 212 | 711.4 | 45.2 |
| 42 | 213 | 670.2 | 44.7 |
| 43 | 214 | 683.7 | 43.6 |
| 44 | 215 | 680.4 | 41.9 |
| 45 | 216 | 464.2 | 38.8 |
| 46 | 217 | 723.6 | 38.1 |
| 47 | 218 | 727.7 | 40.3 |
| 48 | 219 | 496.6 | 40.3 |
| 49 | 220 | 322.4 | 42.5 |
| 50 | 221 | 345.0 | 26.3 |
| 51 | 222 | 307.8 | 18.2 |
| 52 | 223 | 327.7 | 18.4 |
| 53 | 224 | 292.9 | 16.8 |
| 54 | 225 | 215.9 | 15.1 |
| 55 | 226 | 356.7 | 24.6 |
| 56 | 227 | 295.1 | 23.6 |
| 57 | 228 | 334.5 | 23.1 |
| 58 | 229 | 274.1 | 18.9 |
| 59 | 230 | 130.8 | 10.6 |
| 60 | 231 | 178.3 | 20.1 |

Table 18. Concluded.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 61 | 232 | 346.6 | 27.8 |
| 62 | 233 | 326.4 | 31.5 |
| 63 | 234 | 335.2 | 24.3 |
| 64 | 235 | 280.3 | 44.9 |
| 65 | 236 | 219.4 | 19.4 |
| 66 | 239 | 125.2 | 11.3 |
| 67 | 240 | 264.8 | 20.2 |
| 68 | 241 | 256.0 | 15.5 |
| 69 | 242 | 285.9 | 23.2 |
| 70 | 243 | 208.7 | 21.9 |
| 71 | 244 | 86.8 | 8.2 |
| 72 | 245 | 163.9 | 18.7 |
| 73 | 246 | 144.7 | 12.4 |
| 74 | 247 | 277.7 | 26.5 |
| 75 | 248 | 307.3 | 21.0 |
| 76 | 249 | 127.4 | 15.0 |
| 77 | 250 | 212.0 | 24.4 |
| 78 | 251 | 182.0 | 27.4 |
| 79 | 252 | 257.4 | 25.1 |
| 80 | 253 | 235.3 | 16.8 |
| 81 | 254 | 202.5 | 25.3 |
| 82 | 255 | 177.6 | 16.7 |
| 83 | 256 | 259.9 | 18.9 |
| 84 | 257 | 50.6 | 4.1 |
| 85 | 258 | 113.1 | 10.5 |
| 86 | 259 | 163.8 | 11.8 |
| 87 | 260 | 260.3 | 15.3 |
| 88 | 261 | 126.0 | 12.5 |
| 89 | 262 | 211.7 | 16.5 |
| 90 | 263 | 197.0 | 17.9 |
| 91 | 264 | 52.4 | 4.4 |
| 92 | 265 | 34.7 | 3.6 |
| | | 35907.8 | 377.2 |
| Cummulative numerical integral and highest peak (ppb) respectiveiy | | | |

* This integral is obtained by numerical integration of the pollutant concentration with respect to time over the episode duration.

Table 19. Chamber A1 residual treatment $SO_2$ data.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 1 | 166 | 4.4 | 2.5 |
| 2 | 170 | 21.4 | 5.5 |
| 3 | 171 | 41.2 | 24.1 |
| 4 | 174 | 3.1 | 1.5 |
| 5 | 175 | 138.1 | 109.6 |
| 6 | 177 | 2.6 | 0.8 |
| 7 | 179 | 28.3 | 11.5 |
| 8 | 188 | 24.8 | 9.4 |
| 9 | 189 | 27.9 | 5.9 |
| 10 | 191 | 6.0 | 1.3 |
| 11 | 192 | 37.6 | 33.7 |
| 12 | 193 | 17.4 | 4.5 |
| 13 | 195 | 1.4 | 0.6 |
| 14 | 196 | 27.1 | 5.3 |
| 15 | 197 | 6.3 | 2.3 |
| 16 | 201 | 33.7 | 33.7 |
| 17 | 206 | 33.8 | 33.8 |
| 18 | 212 | 2.5 | 1.8 |
| 19 | 219 | 9.6 | 2.1 |
| 20 | 241 | 24.3 | 9.4 |
| 21 | 243 | 59.8 | 10.1 |
| 22 | 244 | 28.5 | 11.8 |
| 23 | 245 | 78.1 | 12.9 |
| 24 | 246 | 16.8 | 6.5 |
| 25 | 247 | 64.3 | 13.1 |
| 26 | 250 | 33.5 | 11.4 |
| 27 | 251 | 88.3 | 15.8 |
| 28 | 252 | 93.6 | 14.9 |
| | | 954.4 | 109.6 |
| Cummulative numerical integral and highest peak (ppb) respectively | | | |

* This integral is obtained by numerical integration of the pollutant concentration with respect to time over the episode duration.

Table 20. Chamber A1 residual treatment $O_3$ treatment data.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 1 | 151 | 203.0 | 24.6 |
| 2 | 152 | 458.2 | 44.6 |
| 3 | 153 | 571.6 | 42.0 |
| 4 | 154 | 266.1 | 30.5 |
| 5 | 155 | 547.7 | 48.6 |
| 6 | 156 | 332.8 | 59.9 |
| 7 | 165 | 323.3 | 62.9 |
| 8 | 166 | 423.6 | 40.7 |
| 9 | 167 | 510.4 | 35.0 |
| 10 | 168 | 494.1 | 59.9 |
| 11 | 169 | 587.1 | 54.3 |
| 12 | 170 | 441.0 | 102.1 |
| 13 | 171 | 474.7 | 31.6 |
| 14 | 172 | 515.2 | 46.7 |
| 15 | 173 | 839.2 | 53.3 |
| 16 | 174 | 616.7 | 66.2 |
| 17 | 175 | 877.1 | 83.3 |
| 18 | 176 | 523.9 | 50.3 |
| 19 | 177 | 675.6 | 65.7 |
| 20 | 178 | 489.8 | 26.7 |
| 21 | 179 | 509.7 | 38.5 |
| 22 | 180 | 608.8 | 36.1 |
| 23 | 181 | 452.2 | 25.8 |
| 24 | 182 | 440.1 | 39.4 |
| 25 | 183 | 466.3 | 28.0 |
| 26 | 184 | 368.1 | 34.6 |
| 27 | 185 | 573.5 | 44.2 |
| 28 | 186 | 758.6 | 42.3 |
| 29 | 187 | 604.5 | 35.7 |
| 30 | 188 | 708.1 | 60.1 |
| 31 | 189 | 775.9 | 66.8 |
| 32 | 190 | 419.2 | 40.6 |
| 33 | 191 | 674.4 | 66.4 |
| 34 | 192 | 605.4 | 51.5 |
| 35 | 193 | 740.8 | 77.3 |
| 36 | 194 | 466.3 | 35.6 |
| 37 | 195 | 461.6 | 46.6 |
| 38 | 196 | 1128.1 | 90.4 |
| 39 | 197 | 711.5 | 65.5 |
| 40 | 198 | 585.5 | 39.4 |
| 41 | 199 | 556.8 | 45.2 |
| 42 | 200 | 696.6 | 43.1 |
| 43 | 201 | 482.7 | 39.8 |
| 44 | 202 | 469.0 | 26.9 |
| 45 | 203 | 352.2 | 28.3 |
| 46 | 204 | 355.9 | 29.4 |
| 47 | 205 | 446.3 | 39.3 |
| 48 | 206 | 844.4 | 65.1 |
| 49 | 207 | 333.6 | 25.6 |
| 50 | 208 | 393.8 | 31.6 |
| 51 | 209 | 561.9 | 51.7 |
| 52 | 210 | 660.6 | 42.7 |
| 53 | 211 | 703.3 | 88.2 |
| 54 | 212 | 887.9 | 61.4 |
| 55 | 213 | 529.2 | 36.7 |
| 56 | 214 | 537.4 | 36.1 |
| 57 | 215 | 823.9 | 57.7 |
| 58 | 216 | 833.5 | 76.2 |
| 59 | 217 | 630.0 | 63.2 |
| 60 | 218 | 560.2 | 34.5 |

continued ...

Table 20. Concluded.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 61 | 219 | 710.5 | 71.5 |
| 62 | 220 | 382.5 | 44.4 |
| 63 | 221 | 315.1 | 23.8 |
| 64 | 222 | 139.9 | 12.0 |
| 65 | 223 | 174.7 | 16.8 |
| 66 | 224 | 185.3 | 12.6 |
| 67 | 225 | 157.8 | 16.2 |
| 68 | 226 | 206.0 | 18.4 |
| 69 | 227 | 140.2 | 15.2 |
| 70 | 228 | 177.5 | 19.4 |
| 71 | 229 | 254.4 | 16.3 |
| 72 | 230 | 113.8 | 10.3 |
| 73 | 231 | 278.9 | 30.6 |
| 74 | 232 | 435.3 | 44.3 |
| 75 | 233 | 241.6 | 18.5 |
| 76 | 234 | 344.0 | 20.4 |
| 77 | 235 | 237.7 | 24.4 |
| 78 | 236 | 511.3 | 33.0 |
| 79 | 237 | 500.4 | 32.9 |
| 80 | 238 | 255.5 | 16.6 |
| 81 | 239 | 119.6 | 13.8 |
| 82 | 240 | 198.9 | 20.0 |
| 83 | 241 | 163.1 | 20.4 |
| 84 | 242 | 438.7 | 48.4 |
| 85 | 243 | 230.2 | 24.0 |
| 86 | 244 | 115.8 | 13.6 |
| 87 | 245 | 162.4 | 16.8 |
| 88 | 246 | 201.2 | 19.8 |
| 89 | 247 | 365.8 | 27.4 |
| 90 | 248 | 277.1 | 18.6 |
| 91 | 249 | 145.8 | 18.4 |
| 92 | 250 | 306.9 | 33.3 |
| 93 | 251 | 320.9 | 34.0 |
| 94 | 252 | 325.4 | 31.3 |
| 95 | 253 | 225.1 | 17.4 |
| 96 | 254 | 198.7 | 22.8 |
| 97 | 255 | 346.8 | 29.0 |
| 98 | 256 | 472.4 | 31.2 |
| 99 | 257 | 87.0 | 7.6 |
| 100 | 258 | 254.9 | 20.5 |
| 101 | 259 | 375.9 | 27.4 |
| 102 | 260 | 372.0 | 21.6 |
| 103 | 261 | 255.9 | 22.1 |
| 104 | 262 | 320.8 | 24.5 |
| 105 | 263 | 354.4 | 27.1 |
| 106 | 264 | 118.5 | 10.6 |
| 107 | 265 | 89.5 | 12.3 |
| | | 46694.8 | 102.1 |
| Cumulative numerical integral and highest peak (ppb) respectively | | | |

* This integral is obtained by numerical integration of the pollutant concentration with respect to time over the episode duration.

Table 21. Chamber A3 residual treatment $SO_2$ data.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 1 | 155 | 2.9 | 2.9 |
| 2 | 170 | 29.1 | 8.6 |
| 3 | 171 | 38.1 | 25.1 |
| 4 | 174 | 5.6 | 2.0 |
| 5 | 175 | 170.8 | 87.4 |
| 6 | 177 | 3.0 | 0.9 |
| 7 | 179 | 25.3 | 9.8 |
| 8 | 188 | 29.1 | 8.4 |
| 9 | 189 | 28.4 | 5.9 |
| 10 | 190 | 1.1 | 1.1 |
| 11 | 191 | 10.1 | 3.2 |
| 12 | 192 | 4.5 | 1.6 |
| 13 | 193 | 21.0 | 6.0 |
| 14 | 195 | 2.3 | 0.6 |
| 15 | 196 | 27.2 | 4.9 |
| 16 | 197 | 7.7 | 2.7 |
| 17 | 212 | 2.5 | 1.6 |
| 18 | 219 | 11.1 | 2.6 |
| 19 | 231 | 1.8 | 1.0 |
| 20 | 241 | 21.9 | 9.0 |
| 21 | 243 | 59.6 | 10.0 |
| 22 | 244 | 9.9 | 4.9 |
| 23 | 245 | 66.8 | 12.4 |
| 24 | 246 | 19.2 | 5.9 |
| 25 | 247 | 55.5 | 10.8 |
| 26 | 248 | 1.5 | 1.0 |
| 27 | 250 | 29.8 | 16.8 |
| 28 | 251 | 47.4 | 7.7 |
| 29 | 252 | 85.0 | 15.4 |
| 30 | 253 | 5.8 | 5.8 |
| | | 824.0 | 87.4 |

Cummulative numerical integral and highest peak (ppb) respectively

* This integral is obtained by numerical integration of the pollutant concentration with respect to time over the episode duration.

Table 22. Chamber A3 residual treatment $O_3$ data.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 1 | 151 | 348.8 | 41.5 |
| 2 | 152 | 740.1 | 60.8 |
| 3 | 153 | 881.8 | 58.0 |
| 4 | 154 | 397.0 | 40.7 |
| 5 | 155 | 849.4 | 72.1 |
| 6 | 156 | 470.9 | 73.1 |
| 7 | 165 | 371.0 | 72.8 |
| 8 | 166 | 616.5 | 55.6 |
| 9 | 167 | 726.1 | 42.6 |
| 10 | 168 | 759.9 | 128.8 |
| 11 | 169 | 683.3 | 60.0 |
| 12 | 170 | 500.7 | 54.2 |
| 13 | 171 | 687.6 | 46.4 |
| 14 | 172 | 736.1 | 60.9 |
| 15 | 173 | 1149.6 | 71.4 |
| 16 | 174 | 795.0 | 84.0 |
| 17 | 175 | 1117.1 | 102.0 |
| 18 | 176 | 784.2 | 65.3 |
| 19 | 177 | 999.4 | 90.3 |
| 20 | 178 | 714.7 | 44.8 |
| 21 | 179 | 630.7 | 50.7 |
| 22 | 180 | 741.1 | 43.6 |
| 23 | 181 | 694.2 | 35.0 |
| 24 | 182 | 699.6 | 61.1 |
| 25 | 183 | 777.4 | 47.2 |
| 26 | 184 | 629.6 | 58.7 |
| 27 | 185 | 941.3 | 73.5 |
| 28 | 186 | 1234.9 | 70.1 |
| 29 | 187 | 980.1 | 56.4 |
| 30 | 188 | 1041.9 | 82.1 |
| 31 | 189 | 1194.9 | 87.6 |
| 32 | 190 | 691.5 | 67.4 |
| 33 | 191 | 1109.6 | 111.2 |
| 34 | 192 | 1003.6 | 76.8 |
| 35 | 193 | 1290.6 | 118.7 |
| 36 | 194 | 766.8 | 60.6 |
| 37 | 195 | 730.8 | 76.0 |
| 38 | 196 | 1808.1 | 132.5 |
| 39 | 197 | 1116.4 | 105.6 |
| 40 | 198 | 880.4 | 59.6 |
| 41 | 199 | 877.8 | 75.7 |
| 42 | 200 | 1096.7 | 67.0 |
| 43 | 201 | 746.0 | 59.5 |
| 44 | 202 | 783.6 | 39.8 |
| 45 | 203 | 566.1 | 43.6 |
| 46 | 204 | 556.8 | 48.8 |
| 47 | 205 | 722.7 | 63.8 |
| 48 | 206 | 1272.9 | 90.5 |
| 49 | 207 | 528.4 | 38.5 |
| 50 | 208 | 630.3 | 53.0 |
| 51 | 209 | 854.6 | 71.3 |
| 52 | 210 | 1021.3 | 65.3 |
| 53 | 211 | 1096.2 | 144.4 |
| 54 | 212 | 1264.5 | 98.2 |
| 55 | 213 | 838.5 | 59.1 |
| 56 | 214 | 822.0 | 59.8 |
| 57 | 215 | 844.1 | 56.9 |
| 58 | 216 | 832.3 | 72.2 |
| 59 | 217 | 1085.7 | 64.6 |
| 60 | 218 | 831.4 | 49.7 |

continued ...

Table 22. Concluded.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 61 | 219 | 1052.1 | 100.2 |
| 62 | 220 | 633.9 | 66.8 |
| 63 | 221 | 546.6 | 38.7 |
| 64 | 222 | 279.5 | 23.7 |
| 65 | 223 | 352.8 | 32.8 |
| 66 | 224 | 354.1 | 21.6 |
| 67 | 225 | 294.4 | 27.9 |
| 68 | 226 | 395.8 | 32.1 |
| 69 | 227 | 271.2 | 29.3 |
| 70 | 228 | 299.3 | 27.5 |
| 71 | 229 | 357.4 | 20.8 |
| 72 | 230 | 206.7 | 15.3 |
| 73 | 231 | 417.3 | 44.0 |
| 74 | 232 | 750.3 | 71.4 |
| 75 | 233 | 419.9 | 29.6 |
| 76 | 234 | 529.1 | 30.5 |
| 77 | 235 | 415.0 | 35.7 |
| 78 | 236 | 781.0 | 44.7 |
| 79 | 237 | 823.9 | 46.4 |
| 80 | 238 | 490.3 | 29.7 |
| 81 | 239 | 249.7 | 21.0 |
| 82 | 240 | 349.7 | 29.1 |
| 83 | 241 | 285.5 | 32.2 |
| 84 | 242 | 632.4 | 59.1 |
| 85 | 243 | 415.7 | 38.1 |
| 86 | 244 | 224.1 | 18.9 |
| 87 | 245 | 307.2 | 28.4 |
| 88 | 246 | 370.1 | 31.2 |
| 89 | 247 | 527.8 | 35.1 |
| 90 | 248 | 423.6 | 33.3 |
| 91 | 249 | 275.8 | 32.2 |
| 92 | 250 | 443.1 | 44.3 |
| 93 | 251 | 411.6 | 52.0 |
| 94 | 252 | 478.6 | 38.2 |
| 95 | 253 | 374.6 | 26.1 |
| 96 | 254 | 310.9 | 30.7 |
| 97 | 255 | 386.1 | 30.9 |
| 98 | 256 | 468.7 | 29.9 |
| 99 | 257 | 93.4 | 8.1 |
| 100 | 258 | 252.7 | 20.6 |
| 101 | 259 | 391.6 | 37.4 |
| 102 | 260 | 376.7 | 21.8 |
| 103 | 261 | 254.8 | 22.4 |
| 104 | 262 | 323.1 | 23.0 |
| 105 | 263 | 355.3 | 26.7 |
| 106 | 264 | 118.3 | 10.3 |
| 107 | 265 | 90.6 | 12.4 |
| | | 69495.1 | 144.4 |
| Cumulative numerical integral and highest peak (ppb) respectively | | | |

* This integral is obtained by numerical integration of the pollutant concentration with respect to time over the episode duration.

Table 23. Chamber B2 residual treatment $SO_2$ data.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 1 | 155 | 6.1 | 3.7 |
| 2 | 166 | 1.5 | 1.2 |
| 3 | 170 | 18.4 | 6.0 |
| 4 | 171 | 36.5 | 24.1 |
| 5 | 174 | 3.0 | 1.1 |
| 6 | 175 | 139.0 | 105.2 |
| 7 | 179 | 21.3 | 10.3 |
| 8 | 188 | 28.5 | 9.4 |
| 9 | 189 | 25.6 | 5.6 |
| 10 | 191 | 10.5 | 3.3 |
| 11 | 192 | 3.2 | 1.2 |
| 12 | 193 | 26.6 | 6.0 |
| 13 | 196 | 26.1 | 4.8 |
| 14 | 197 | 4.4 | 2.0 |
| 15 | 212 | 2.6 | 1.9 |
| 16 | 219 | 5.5 | 1.3 |
| 17 | 220 | 77.7 | 77.7 |
| 18 | 231 | 1.5 | 1.4 |
| 19 | 241 | 21.5 | 8.6 |
| 20 | 243 | 67.5 | 10.6 |
| 21 | 244 | 8.1 | 3.1 |
| 22 | 245 | 43.1 | 6.9 |
| 23 | 246 | 20.7 | 7.7 |
| 24 | 247 | 52.7 | 11.6 |
| 25 | 248 | 9.5 | 7.5 |
| 26 | 250 | 34.3 | 11.8 |
| 27 | 251 | 48.0 | 9.9 |
| 28 | 252 | 94.1 | 14.8 |
| 29 | 255 | 10.1 | 9.5 |
| | | 847.6 | 105.2 |
| Cummulative numerical integral and highest peak (ppb) respectively | | | |

* This integral is obtained by numerical integration of the pollutant concentration with respect to time over the episode duration.

Table 24. Chamber B2 residual treatment $O_3$ data.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 1 | 151 | 350.7 | 41.2 |
| 2 | 152 | 734.6 | 59.0 |
| 3 | 153 | 868.6 | 54.8 |
| 4 | 154 | 405.4 | 41.8 |
| 5 | 155 | 831.7 | 69.6 |
| 6 | 156 | 700.9 | 277.1 |
| 7 | 165 | 373.6 | 74.1 |
| 8 | 166 | 620.2 | 55.5 |
| 9 | 167 | 722.2 | 42.8 |
| 10 | 168 | 755.4 | 109.1 |
| 11 | 169 | 669.1 | 59.1 |
| 12 | 170 | 582.0 | 91.3 |
| 13 | 171 | 689.6 | 47.0 |
| 14 | 172 | 751.6 | 61.8 |
| 15 | 173 | 1138.5 | 71.2 |
| 16 | 174 | 779.0 | 83.4 |
| 17 | 175 | 1114.0 | 100.4 |
| 18 | 176 | 791.2 | 63.9 |
| 19 | 177 | 992.9 | 88.8 |
| 20 | 178 | 730.7 | 43.3 |
| 21 | 179 | 636.2 | 50.5 |
| 22 | 180 | 717.4 | 43.3 |
| 23 | 181 | 654.3 | 33.1 |
| 24 | 182 | 684.7 | 59.1 |
| 25 | 183 | 742.6 | 43.3 |
| 26 | 184 | 632.0 | 57.9 |
| 27 | 185 | 931.1 | 73.0 |
| 28 | 186 | 1230.1 | 74.3 |
| 29 | 187 | 972.5 | 56.5 |
| 30 | 188 | 1046.6 | 80.8 |
| 31 | 189 | 1233.9 | 86.7 |
| 32 | 190 | 689.6 | 68.1 |
| 33 | 191 | 1109.1 | 108.3 |
| 34 | 192 | 1007.1 | 77.3 |
| 35 | 193 | 1309.1 | 120.4 |
| 36 | 194 | 765.0 | 60.4 |
| 37 | 195 | 739.1 | 74.6 |
| 38 | 196 | 1841.8 | 133.5 |
| 39 | 197 | 1143.5 | 105.9 |
| 40 | 198 | 899.2 | 59.5 |
| 41 | 199 | 905.3 | 76.2 |
| 42 | 200 | 1114.5 | 65.6 |
| 43 | 201 | 769.2 | 60.7 |
| 44 | 202 | 802.5 | 41.9 |
| 45 | 203 | 587.2 | 43.6 |
| 46 | 204 | 588.1 | 49.5 |
| 47 | 205 | 740.1 | 63.1 |
| 48 | 206 | 1251.1 | 90.4 |
| 49 | 207 | 541.1 | 41.0 |
| 50 | 208 | 640.1 | 52.3 |
| 51 | 209 | 845.2 | 68.8 |
| 52 | 210 | 1033.5 | 65.3 |
| 53 | 211 | 1102.3 | 144.8 |
| 54 | 212 | 1246.6 | 84.8 |
| 55 | 213 | 836.8 | 60.3 |
| 56 | 214 | 895.2 | 59.5 |
| 57 | 215 | 861.2 | 59.6 |
| 58 | 216 | 833.6 | 75.5 |
| 59 | 217 | 1063.5 | 64.3 |
| 60 | 218 | 813.6 | 49.2 |

continued ...

Table 24. Concluded.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 61 | 219 | 1034.0 | 97.7 |
| 62 | 220 | 607.9 | 62.8 |
| 63 | 221 | 546.6 | 38.0 |
| 64 | 222 | 289.9 | 23.6 |
| 65 | 223 | 357.6 | 32.3 |
| 66 | 224 | 358.9 | 21.3 |
| 67 | 225 | 296.3 | 28.9 |
| 68 | 226 | 403.9 | 32.8 |
| 69 | 227 | 273.4 | 28.9 |
| 70 | 228 | 306.3 | 27.2 |
| 71 | 229 | 357.0 | 20.6 |
| 72 | 230 | 208.9 | 14.8 |
| 73 | 231 | 418.6 | 41.8 |
| 74 | 232 | 754.3 | 65.3 |
| 75 | 233 | 424.8 | 29.7 |
| 76 | 234 | 512.0 | 30.5 |
| 77 | 235 | 413.7 | 35.5 |
| 78 | 236 | 753.8 | 43.0 |
| 79 | 237 | 805.4 | 44.5 |
| 80 | 238 | 501.2 | 31.2 |
| 81 | 239 | 238.4 | 20.4 |
| 82 | 240 | 346.1 | 28.9 |
| 83 | 241 | 281.3 | 30.9 |
| 84 | 242 | 625.5 | 57.2 |
| 85 | 243 | 413.7 | 36.6 |
| 86 | 244 | 220.5 | 19.8 |
| 87 | 245 | 309.0 | 28.0 |
| 88 | 246 | 365.3 | 30.7 |
| 89 | 247 | 522.6 | 34.7 |
| 90 | 248 | 420.3 | 22.6 |
| 91 | 249 | 272.7 | 31.5 |
| 92 | 250 | 438.7 | 43.8 |
| 93 | 251 | 413.9 | 51.5 |
| 94 | 252 | 481.1 | 38.0 |
| 95 | 253 | 362.7 | 25.0 |
| 96 | 254 | 302.0 | 29.8 |
| 97 | 255 | 388.1 | 30.2 |
| 98 | 256 | 479.3 | 30.6 |
| 99 | 257 | 91.3 | 7.5 |
| 100 | 258 | 248.2 | 20.0 |
| 101 | 259 | 364.5 | 26.8 |
| 102 | 260 | 364.0 | 21.1 |
| 103 | 261 | 247.0 | 31.5 |
| 104 | 262 | 311.0 | 22.0 |
| 105 | 263 | 346.7 | 20.1 |
| 106 | 264 | 117.5 | 10.2 |
| 107 | 265 | 90.0 | 12.4 |
| | | 69745.4 | 277.1 |
| Cummulative numerical integral and highest peak (ppb) respectively | | | |

* This integral is obtained by numerical integration of the pollutant concentration with respect to time over the episode duration.

Table 25. Chamber B3 residual treatment $SO_2$ data.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 1 | 170 | 40.5 | 10.1 |
| 2 | 171 | 52.4 | 26.5 |
| 3 | 173 | 1.6 | 0.8 |
| 4 | 174 | 3.7 | 1.5 |
| 5 | 175 | 47.6 | 16.6 |
| 6 | 177 | 5.0 | 1.5 |
| 7 | 179 | 20.0 | 6.2 |
| 8 | 188 | 20.5 | 9.7 |
| 9 | 189 | 28.2 | 5.7 |
| 10 | 191 | 3.1 | 0.9 |
| 11 | 192 | 5.1 | 2.0 |
| 12 | 193 | 19.0 | 5.2 |
| 13 | 195 | 3.1 | 1.0 |
| 14 | 196 | 26.4 | 4.7 |
| 15 | 197 | 7.8 | 2.5 |
| 16 | 212 | 2.3 | 1.8 |
| 17 | 219 | 11.5 | 2.7 |
| 18 | 228 | 30.4 | 30.4 |
| 19 | 230 | 2.2 | 2.2 |
| 20 | 231 | 2.2 | 1.0 |
| 21 | 240 | 2.8 | 2.8 |
| 22 | 241 | 23.5 | 10.1 |
| 23 | 242 | 10.0 | 10.0 |
| 24 | 243 | 35.0 | 8.8 |
| 25 | 244 | 20.3 | 6.1 |
| 26 | 245 | 70.9 | 10.3 |
| 27 | 246 | 35.0 | 5.9 |
| 28 | 247 | 43.8 | 10.6 |
| 29 | 248 | 3.3 | 3.3 |
| 30 | 250 | 43.7 | 14.2 |
| 31 | 251 | 77.6 | 26.1 |
| 32 | 252 | 87.4 | 14.7 |
| 33 | 253 | 14.6 | 12.9 |
| | | 800.5 | 26.5 |
| Cummulative numerical integral and highest peak (ppb) respectively | | | |

* This integral is obtained by numerical integration of the pollutant concentration with respect to time over the episode duration.

Table 26. Chamber B3 residual treatment $O_3$ data.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 1 | 151 | 245.1 | 33.3 |
| 2 | 152 | 498.0 | 42.8 |
| 3 | 153 | 605.0 | 40.2 |
| 4 | 154 | 283.0 | 27.5 |
| 5 | 155 | 567.9 | 49.2 |
| 6 | 156 | 158.4 | 34.8 |
| 7 | 165 | 314.4 | 52.6 |
| 8 | 166 | 449.4 | 38.8 |
| 9 | 167 | 535.1 | 30.0 |
| 10 | 168 | 552.7 | 83.9 |
| 11 | 169 | 557.9 | 52.3 |
| 12 | 170 | 451.4 | 96.8 |
| 13 | 171 | 495.6 | 33.9 |
| 14 | 172 | 554.8 | 46.5 |
| 15 | 173 | 868.4 | 56.9 |
| 16 | 174 | 565.0 | 63.0 |
| 17 | 175 | 890.8 | 77.2 |
| 18 | 176 | 575.7 | 51.6 |
| 19 | 177 | 751.4 | 67.9 |
| 20 | 178 | 533.7 | 32.0 |
| 21 | 179 | 489.0 | 43.2 |
| 22 | 180 | 580.5 | 37.4 |
| 23 | 181 | 520.0 | 28.0 |
| 24 | 182 | 503.2 | 45.7 |
| 25 | 183 | 565.8 | 32.4 |
| 26 | 184 | 445.4 | 41.3 |
| 27 | 185 | 704.1 | 55.5 |
| 28 | 186 | 909.0 | 51.4 |
| 29 | 187 | 707.4 | 42.2 |
| 30 | 188 | 823.1 | 65.1 |
| 31 | 189 | 901.6 | 75.8 |
| 32 | 190 | 512.0 | 50.8 |
| 33 | 191 | 815.6 | 79.0 |
| 34 | 192 | 723.3 | 61.0 |
| 35 | 193 | 891.4 | 94.4 |
| 36 | 194 | 570.9 | 44.0 |
| 37 | 195 | 541.2 | 55.8 |
| 38 | 196 | 1323.1 | 102.5 |
| 39 | 197 | 856.2 | 79.3 |
| 40 | 198 | 699.5 | 46.7 |
| 41 | 199 | 660.3 | 56.4 |
| 42 | 200 | 838.5 | 50.3 |
| 43 | 201 | 566.8 | 45.0 |
| 44 | 202 | 572.3 | 30.9 |
| 45 | 203 | 421.0 | 35.3 |
| 46 | 204 | 436.5 | 36.6 |
| 47 | 205 | 528.7 | 44.5 |
| 48 | 206 | 996.1 | 71.9 |
| 49 | 207 | 398.7 | 29.8 |
| 50 | 208 | 468.4 | 38.5 |
| 51 | 209 | 659.8 | 58.2 |
| 52 | 210 | 767.4 | 49.5 |
| 53 | 211 | 806.1 | 103.6 |
| 54 | 212 | 945.7 | 65.5 |
| 55 | 213 | 628.7 | 46.4 |
| 56 | 214 | 654.3 | 44.1 |
| 57 | 215 | 630.4 | 42.4 |
| 58 | 216 | 653.9 | 60.2 |
| 59 | 217 | 867.8 | 51.9 |
| 60 | 218 | 669.1 | 41.4 |

continued ...

Table 26. Concluded.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 61 | 219 | 800.0 | 77.2 |
| 62 | 220 | 463.8 | 48.8 |
| 63 | 221 | 406.9 | 31.6 |
| 64 | 222 | 185.8 | 15.9 |
| 65 | 223 | 230.7 | 22.7 |
| 66 | 224 | 252.1 | 16.9 |
| 67 | 225 | 202.8 | 19.5 |
| 68 | 226 | 275.7 | 22.5 |
| 69 | 227 | 187.0 | 20.5 |
| 70 | 228 | 219.1 | 20.5 |
| 71 | 229 | 299.9 | 17.7 |
| 72 | 230 | 161.9 | 12.7 |
| 73 | 231 | 315.9 | 32.9 |
| 74 | 232 | 542.3 | 52.1 |
| 75 | 233 | 284.9 | 21.6 |
| 76 | 234 | 428.5 | 24.8 |
| 77 | 235 | 309.1 | 29.6 |
| 78 | 236 | 601.9 | 36.9 |
| 79 | 237 | 606.4 | 38.5 |
| 80 | 238 | 327.4 | 20.5 |
| 81 | 239 | 158.5 | 14.5 |
| 82 | 240 | 236.9 | 22.5 |
| 83 | 241 | 193.0 | 23.5 |
| 84 | 242 | 488.3 | 51.2 |
| 85 | 243 | 294.3 | 28.1 |
| 86 | 244 | 155.4 | 15.1 |
| 87 | 245 | 222.6 | 20.7 |
| 88 | 246 | 259.1 | 22.6 |
| 89 | 247 | 414.8 | 30.1 |
| 90 | 248 | 346.7 | 21.7 |
| 91 | 249 | 194.6 | 23.2 |
| 92 | 250 | 346.4 | 35.1 |
| 93 | 251 | 282.8 | 39.1 |
| 94 | 252 | 385.2 | 33.9 |
| 95 | 253 | 282.3 | 20.6 |
| 96 | 254 | 219.9 | 23.6 |
| 97 | 255 | 279.0 | 25.2 |
| 98 | 256 | 382.0 | 27.4 |
| 99 | 257 | 51.2 | 4.2 |
| 100 | 258 | 149.9 | 14.7 |
| 101 | 259 | 264.9 | 20.9 |
| 102 | 260 | 249.2 | 14.1 |
| 103 | 261 | 180.3 | 17.9 |
| 104 | 262 | 212.4 | 18.2 |
| 105 | 263 | 241.0 | 19.1 |
| 106 | 264 | 66.3 | 6.1 |
| 107 | 265 | 47.6 | 7.1 |
| | | 51413.2 | 103.6 |
| Cummulative numerical integral and highest peak (ppb) respectively | | | |

* This integral is obtained by numerical integration of the pollutant concentration with respect to time over the episode duration.

Table 27. Chamber D1 residual treatment $SO_2$ data.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 1 | 166 | 2.5 | 1.2 |
| 2 | 170 | 36.0 | 9.2 |
| 3 | 171 | 49.6 | 22.0 |
| 4 | 173 | 1.9 | 0.6 |
| 5 | 174 | 7.8 | 2.7 |
| 6 | 175 | 41.1 | 11.6 |
| 7 | 177 | 3.7 | 1.0 |
| 8 | 179 | 27.5 | 13.5 |
| 9 | 188 | 30.2 | 16.1 |
| 10 | 189 | 30.1 | 6.4 |
| 11 | 191 | 15.7 | 4.8 |
| 12 | 192 | 7.5 | 2.9 |
| 13 | 193 | 23.3 | 7.0 |
| 14 | 194 | 1.7 | 0.9 |
| 15 | 195 | 2.8 | 0.7 |
| 16 | 196 | 27.4 | 5.1 |
| 17 | 197 | 8.4 | 3.0 |
| 18 | 212 | 3.0 | 2.2 |
| 19 | 219 | 11.4 | 2.7 |
| 20 | 230 | 1.6 | 1.6 |
| 21 | 231 | 2.2 | 2.2 |
| 22 | 240 | 4.8 | 4.8 |
| 23 | 241 | 23.0 | 9.4 |
| 24 | 243 | 36.8 | 8.6 |
| 25 | 244 | 24.1 | 6.7 |
| 26 | 245 | 1.1 | 9.1 |
| 27 | 246 | 13.1 | 5.7 |
| 28 | 247 | 44.8 | 9.7 |
| 29 | 250 | 35.8 | 16.2 |
| 30 | 251 | 83.8 | 21.9 |
| 31 | 252 | 87.3 | 15.4 |
| 32 | 253 | 12.9 | 11.1 |
| | | 772.9 | 22.0 |

Cummulative numerical integral and highest peak (ppb) respectively

* This integral is obtained by numerical integration of the pollutant concentration with respect to time over the episode duration.

Table 28. Chamber D1 residual treatment $O_3$ data.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 1 | 151 | 240.8 | 33.6 |
| 2 | 152 | 506.2 | 44.5 |
| 3 | 153 | 604.7 | 43.1 |
| 4 | 154 | 270.6 | 28.4 |
| 5 | 155 | 556.1 | 49.6 |
| 6 | 156 | 327.4 | 42.8 |
| 7 | 165 | 444.4 | 75.3 |
| 8 | 166 | 636.7 | 59.2 |
| 9 | 167 | 733.4 | 42.7 |
| 10 | 168 | 740.2 | 79.8 |
| 11 | 169 | 721.0 | 64.5 |
| 12 | 170 | 473.8 | 38.5 |
| 13 | 171 | 692.4 | 48.4 |
| 14 | 172 | 783.7 | 64.7 |
| 15 | 173 | 1192.6 | 73.4 |
| 16 | 174 | 807.8 | 87.0 |
| 17 | 175 | 1158.7 | 104.1 |
| 18 | 176 | 833.4 | 74.3 |
| 19 | 177 | 1037.3 | 91.9 |
| 20 | 178 | 769.3 | 47.5 |
| 21 | 179 | 610.1 | 51.3 |
| 22 | 180 | 758.8 | 45.3 |
| 23 | 181 | 707.8 | 34.9 |
| 24 | 182 | 720.7 | 62.5 |
| 25 | 183 | 808.1 | 49.2 |
| 26 | 184 | 658.1 | 61.4 |
| 27 | 185 | 976.5 | 76.4 |
| 28 | 186 | 1287.4 | 75.0 |
| 29 | 187 | 1023.8 | 59.9 |
| 30 | 188 | 1096.2 | 84.1 |
| 31 | 189 | 1242.6 | 90.2 |
| 32 | 190 | 722.7 | 72.1 |
| 33 | 191 | 1174.2 | 116.8 |
| 34 | 192 | 1029.8 | 80.2 |
| 35 | 193 | 1355.9 | 129.1 |
| 36 | 194 | 817.1 | 64.6 |
| 37 | 195 | 774.1 | 78.3 |
| 38 | 196 | 1899.3 | 134.8 |
| 39 | 197 | 1176.8 | 111.2 |
| 40 | 198 | 919.4 | 62.7 |
| 41 | 199 | 940.9 | 79.7 |
| 42 | 200 | 1162.3 | 70.1 |
| 43 | 201 | 805.0 | 62.3 |
| 44 | 202 | 847.6 | 47.1 |
| 45 | 203 | 601.3 | 45.6 |
| 46 | 204 | 626.4 | 52.3 |
| 47 | 205 | 776.8 | 66.6 |
| 48 | 206 | 1332.9 | 97.8 |
| 49 | 207 | 567.1 | 43.1 |
| 50 | 208 | 678.5 | 56.5 |
| 51 | 209 | 894.0 | 74.2 |
| 52 | 210 | 1077.3 | 68.8 |
| 53 | 211 | 1151.8 | 150.9 |
| 54 | 212 | 1331.3 | 92.3 |
| 55 | 213 | 886.0 | 62.2 |
| 56 | 214 | 933.4 | 62.5 |
| 57 | 215 | 894.3 | 59.7 |
| 58 | 216 | 865.5 | 78.4 |
| 59 | 217 | 1114.1 | 65.4 |
| 60 | 218 | 861.1 | 51.8 |

continued ...

Table 28. Concluded.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 61 | 219 | 1096.6 | 102.9 |
| 62 | 220 | 642.3 | 67.7 |
| 63 | 221 | 567.5 | 39.6 |
| 64 | 222 | 301.2 | 24.5 |
| 65 | 223 | 568.1 | 34.0 |
| 66 | 224 | 383.7 | 24.2 |
| 67 | 225 | 310.2 | 30.0 |
| 68 | 226 | 419.9 | 34.1 |
| 69 | 227 | 293.3 | 31.3 |
| 70 | 228 | 326.2 | 28.8 |
| 71 | 229 | 378.0 | 21.2 |
| 72 | 230 | 219.7 | 15.1 |
| 73 | 231 | 440.7 | 44.3 |
| 74 | 232 | 787.9 | 74.2 |
| 75 | 233 | 427.9 | 29.9 |
| 76 | 234 | 543.1 | 32.3 |
| 77 | 235 | 429.8 | 37.3 |
| 78 | 236 | 797.5 | 45.0 |
| 79 | 237 | 858.7 | 48.0 |
| 80 | 238 | 506.5 | 30.4 |
| 81 | 239 | 269.2 | 21.2 |
| 82 | 240 | 374.9 | 30.7 |
| 83 | 241 | 297.4 | 33.6 |
| 84 | 242 | 650.9 | 60.1 |
| 85 | 243 | 421.8 | 37.7 |
| 86 | 244 | 228.8 | 19.8 |
| 87 | 245 | 321.2 | 29.4 |
| 88 | 246 | 385.4 | 32.8 |
| 89 | 247 | 542.4 | 34.5 |
| 90 | 248 | 434.8 | 24.4 |
| 91 | 249 | 283.4 | 32.9 |
| 92 | 250 | 463.0 | 46.0 |
| 93 | 251 | 412.9 | 53.2 |
| 94 | 252 | 503.8 | 40.9 |
| 95 | 253 | 383.6 | 26.5 |
| 96 | 254 | 329.6 | 32.8 |
| 97 | 255 | 400.6 | 30.5 |
| 98 | 256 | 488.1 | 31.9 |
| 99 | 257 | 98.9 | 8.1 |
| 100 | 258 | 265.7 | 21.6 |
| 101 | 259 | 398.8 | 28.8 |
| 102 | 260 | 394.5 | 22.7 |
| 103 | 261 | 271.3 | 23.1 |
| 104 | 262 | 339.9 | 23.7 |
| 105 | 263 | 370.3 | 27.9 |
| 106 | 264 | 127.5 | 10.9 |
| 107 | 265 | 97.5 | 13.7 |
| | | 71292.5 | 150.9 |
| Cummulative numerical integral and highest peak (ppb) respectively | | | |

* This integral is obtained by numerical integration of the pollutant concentration with respect to time over the episode duration.

Table 29. Chamber D5 residual treatment $SO_2$ data.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 1 | 169 | 1.6 | 0.9 |
| 2 | 170 | 26.3 | 9.1 |
| 3 | 171 | 52.4 | 26.7 |
| 4 | 173 | 2.8 | 0.6 |
| 5 | 174 | 3.9 | 1.5 |
| 6 | 175 | 94.3 | 59.4 |
| 7 | 177 | 3.8 | 0.8 |
| 8 | 179 | 4.5 | 2.9 |
| 9 | 188 | 15.0 | 7.4 |
| 10 | 189 | 29.9 | 6.3 |
| 11 | 191 | 4.2 | 1.1 |
| 12 | 192 | 5.4 | 2.1 |
| 13 | 193 | 18.6 | 5.1 |
| 14 | 194 | 1.7 | 0.9 |
| 15 | 195 | 3.9 | 1.0 |
| 16 | 196 | 27.2 | 4.9 |
| 17 | 197 | 7.6 | 2.6 |
| 18 | 212 | 2.3 | 1.8 |
| 19 | 219 | 13.6 | 2.7 |
| 20 | 220 | 16.7 | 16.7 |
| 21 | 230 | 1.3 | 0.8 |
| 22 | 241 | 23.3 | 9.3 |
| 23 | 242 | 11.7 | 11.7 |
| 24 | 243 | 46.3 | 7.4 |
| 25 | 244 | 26.8 | 6.2 |
| 26 | 245 | 45.1 | 11.3 |
| 27 | 246 | 22.7 | 5.2 |
| 28 | 247 | 57.3 | 11.4 |
| 29 | 248 | 5.7 | 5.7 |
| 30 | 250 | 33.7 | 8.9 |
| 31 | 251 | 54.3 | 17.5 |
| 32 | 252 | 65.1 | 12.0 |
| 33 | 253 | 13.1 | 11.6 |
| | | 742.1 | 59.4 |

Cummulative numerical integral and highest peak (ppb) respectively

* This integral is obtained by numerical integration of the pollutant concentration with respect to time over the episode duration.

Table 30. Chamber D5 residual treatment $O_3$ data.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 1 | 151 | 219.0 | 27.5 |
| 2 | 152 | 480.5 | 45.0 |
| 3 | 153 | 579.3 | 44.6 |
| 4 | 154 | 254.9 | 24.5 |
| 5 | 155 | 521.1 | 46.0 |
| 6 | 156 | 289.5 | 39.8 |
| 7 | 165 | 301.8 | 52.9 |
| 8 | 166 | 429.4 | 40.3 |
| 9 | 167 | 485.3 | 28.3 |
| 10 | 168 | 519.8 | 68.9 |
| 11 | 169 | 525.1 | 52.1 |
| 12 | 170 | 447.6 | 101.9 |
| 13 | 171 | 447.5 | 30.6 |
| 14 | 172 | 514.2 | 44.0 |
| 15 | 173 | 822.0 | 56.9 |
| 16 | 174 | 510.7 | 59.0 |
| 17 | 175 | 839.2 | 72.1 |
| 18 | 176 | 539.3 | 49.1 |
| 19 | 177 | 737.7 | 65.8 |
| 20 | 178 | 498.4 | 29.3 |
| 21 | 179 | 478.3 | 51.7 |
| 22 | 180 | 562.5 | 37.3 |
| 23 | 181 | 506.5 | 28.1 |
| 24 | 182 | 478.5 | 41.8 |
| 25 | 183 | 506.6 | 28.5 |
| 26 | 184 | 399.9 | 37.7 |
| 27 | 185 | 624.2 | 48.8 |
| 28 | 186 | 812.8 | 44.6 |
| 29 | 187 | 635.1 | 37.0 |
| 30 | 188 | 744.1 | 57.8 |
| 31 | 189 | 858.0 | 71.7 |
| 32 | 190 | 459.0 | 44.4 |
| 33 | 191 | 738.5 | 73.7 |
| 34 | 192 | 680.3 | 56.3 |
| 35 | 193 | 814.2 | 80.9 |
| 36 | 194 | 510.9 | 38.9 |
| 37 | 195 | 501.4 | 49.3 |
| 38 | 196 | 1218.6 | 97.6 |
| 39 | 197 | 776.4 | 72.9 |
| 40 | 198 | 678.2 | 46.5 |
| 41 | 199 | 584.5 | 51.1 |
| 42 | 200 | 791.3 | 50.4 |
| 43 | 201 | 514.1 | 42.0 |
| 44 | 202 | 527.1 | 28.6 |
| 45 | 203 | 388.3 | 29.3 |
| 46 | 204 | 392.2 | 32.9 |
| 47 | 205 | 477.6 | 40.2 |
| 48 | 206 | 904.5 | 66.3 |
| 49 | 207 | 358.0 | 26.6 |
| 50 | 208 | 421.8 | 34.2 |
| 51 | 209 | 583.2 | 49.9 |
| 52 | 210 | 695.8 | 42.7 |
| 53 | 211 | 707.9 | 91.6 |
| 54 | 212 | 837.3 | 57.7 |
| 55 | 213 | 568.0 | 40.4 |
| 56 | 214 | 583.3 | 38.5 |
| 57 | 215 | 568.1 | 37.6 |
| 58 | 216 | 596.4 | 57.9 |
| 59 | 217 | 802.8 | 50.8 |
| 60 | 218 | 629.6 | 38.1 |

continued ...

Table 30. Concluded.

| Episode | J-day | Integral* | Peak |
|---|---|---|---|
| 61 | 219 | 781.9 | 77.3 |
| 62 | 220 | 406.5 | 45.8 |
| 63 | 221 | 378.6 | 29.5 |
| 64 | 222 | 168.7 | 14.0 |
| 65 | 223 | 205.5 | 20.3 |
| 66 | 224 | 222.1 | 13.7 |
| 67 | 225 | 179.7 | 18.8 |
| 68 | 226 | 242.4 | 20.2 |
| 69 | 227 | 161.4 | 17.9 |
| 70 | 228 | 178.4 | 18.4 |
| 71 | 229 | 250.0 | 17.7 |
| 72 | 230 | 145.2 | 13.5 |
| 73 | 231 | 297.5 | 32.6 |
| 74 | 232 | 470.3 | 44.3 |
| 75 | 233 | 261.0 | 19.5 |
| 76 | 234 | 391.4 | 23.1 |
| 77 | 235 | 250.5 | 23.2 |
| 78 | 236 | 518.4 | 32.5 |
| 79 | 237 | 513.4 | 31.4 |
| 80 | 238 | 276.4 | 17.4 |
| 81 | 239 | 130.6 | 13.2 |
| 82 | 240 | 197.2 | 18.4 |
| 83 | 241 | 160.7 | 18.8 |
| 84 | 242 | 442.7 | 44.1 |
| 85 | 243 | 304.8 | 27.9 |
| 86 | 244 | 152.1 | 14.2 |
| 87 | 245 | 224.8 | 20.7 |
| 88 | 246 | 251.9 | 22.1 |
| 89 | 247 | 377.6 | 27.3 |
| 90 | 248 | 333.2 | 19.6 |
| 91 | 249 | 192.8 | 23.2 |
| 92 | 250 | 328.1 | 32.6 |
| 93 | 251 | 272.9 | 36.3 |
| 94 | 252 | 343.8 | 29.2 |
| 95 | 253 | 281.1 | 21.4 |
| 96 | 254 | 196.6 | 20.4 |
| 97 | 255 | 260.7 | 22.5 |
| 98 | 256 | 348.6 | 24.5 |
| 99 | 257 | 46.6 | 4.6 |
| 100 | 258 | 148.6 | 13.4 |
| 101 | 259 | 250.9 | 20.0 |
| 102 | 260 | 254.2 | 14.5 |
| 103 | 261 | 174.0 | 17.2 |
| 104 | 262 | 208.3 | 15.9 |
| 105 | 263 | 230.3 | 18.9 |
| 106 | 264 | 64.2 | 6.2 |
| 107 | 265 | 47.9 | 7.1 |
| | | 47402.6 | 101.9 |
| Cummulative numerical integral and highest peak (ppb) respectively | | | |

* This integral is obtained by numerical integration of the pollutant concentration with respect to time over the episode duration.

## 6.4 TIME SERIES OF POLLUTANT EPISODES

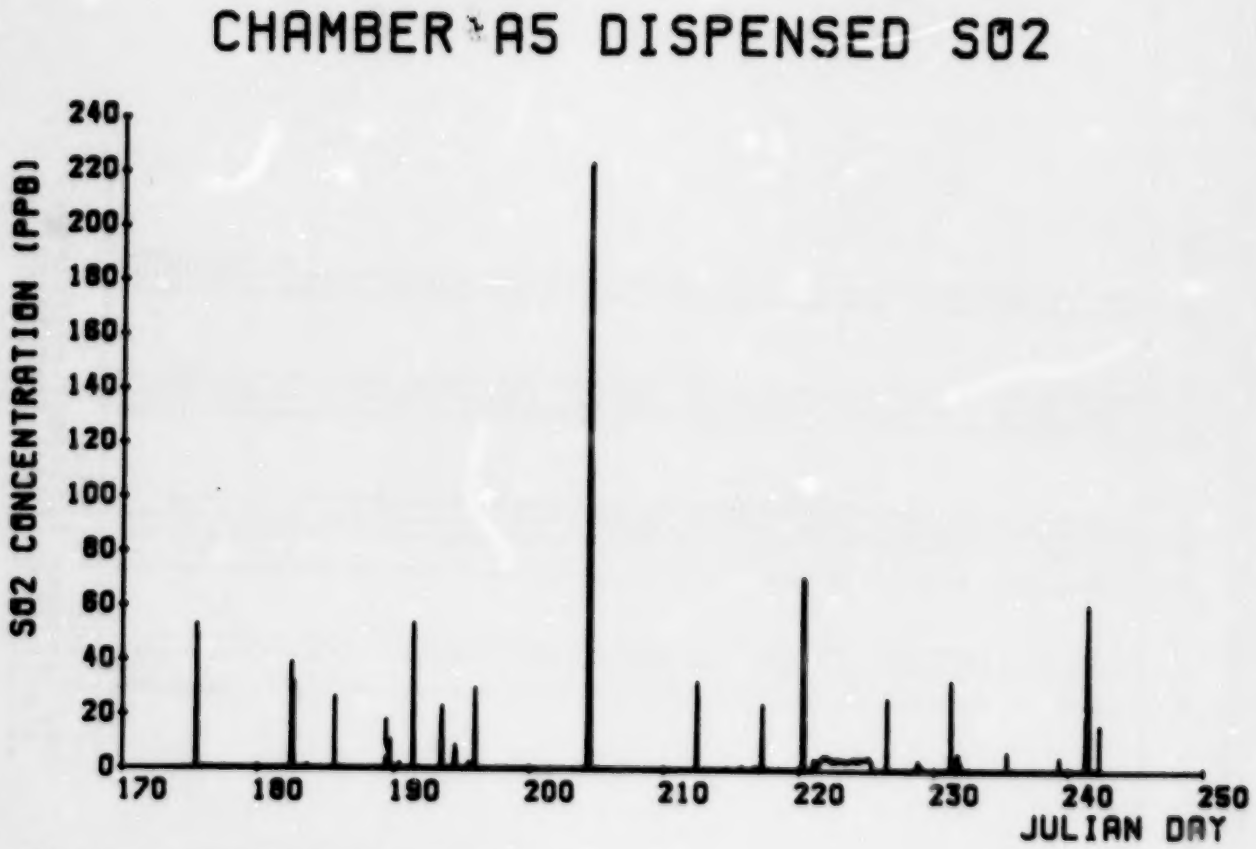


Figure 1. Chamber A5-dispensed $SO_2$.

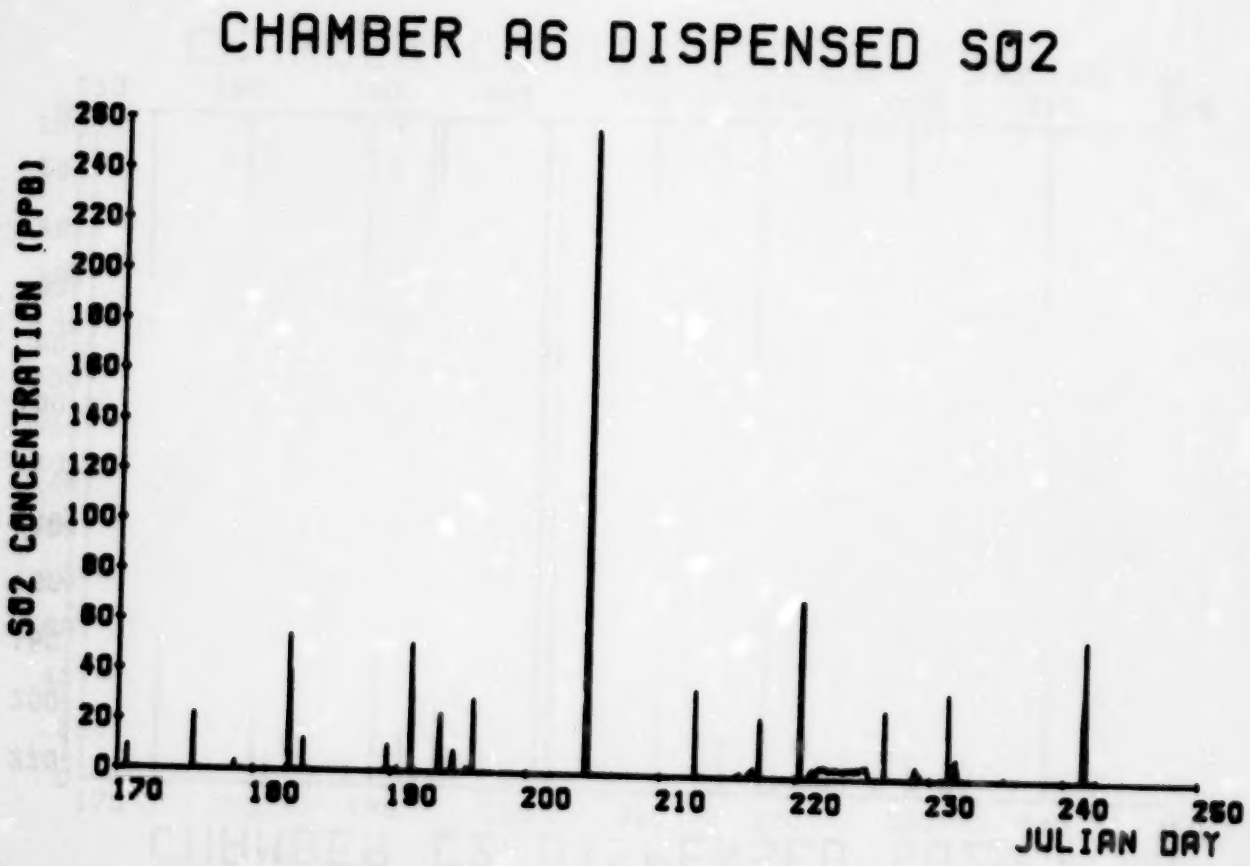


Figure 2. Chamber A6-dispensed $SO_2$.

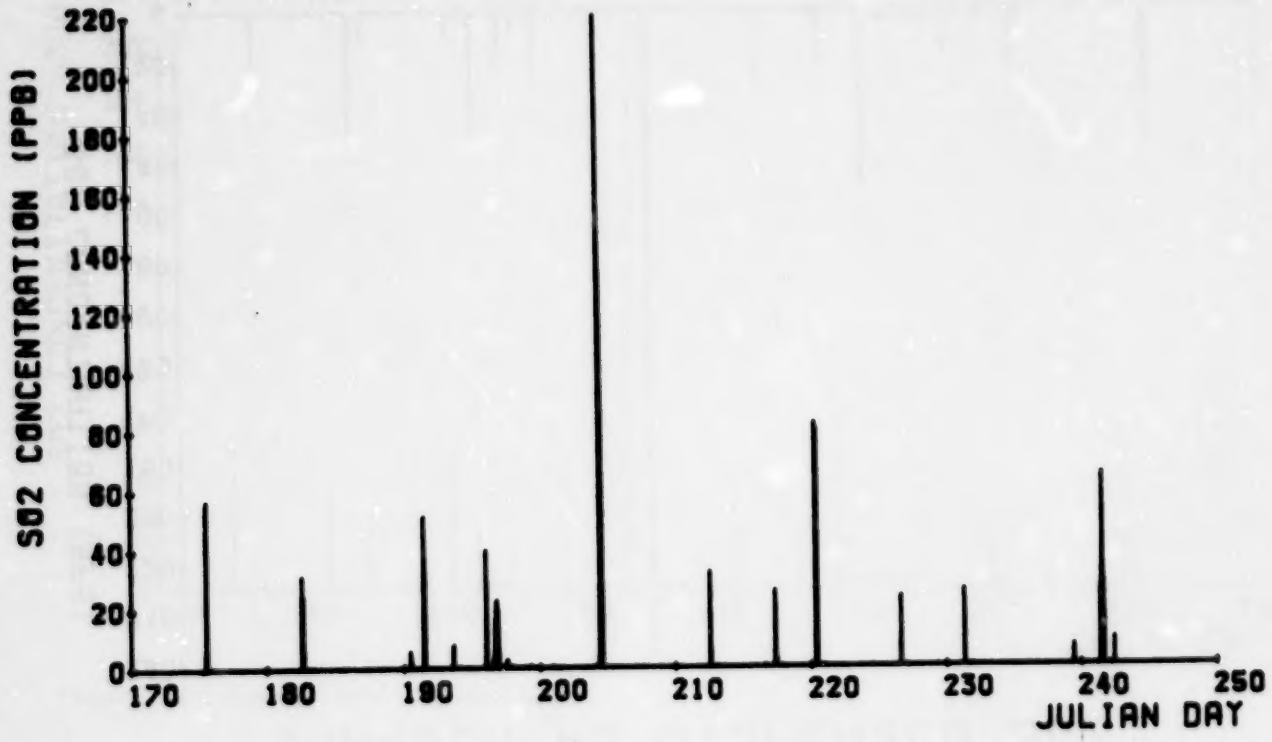


Figure 3. Chamber C2-dispensed $SO_2$.

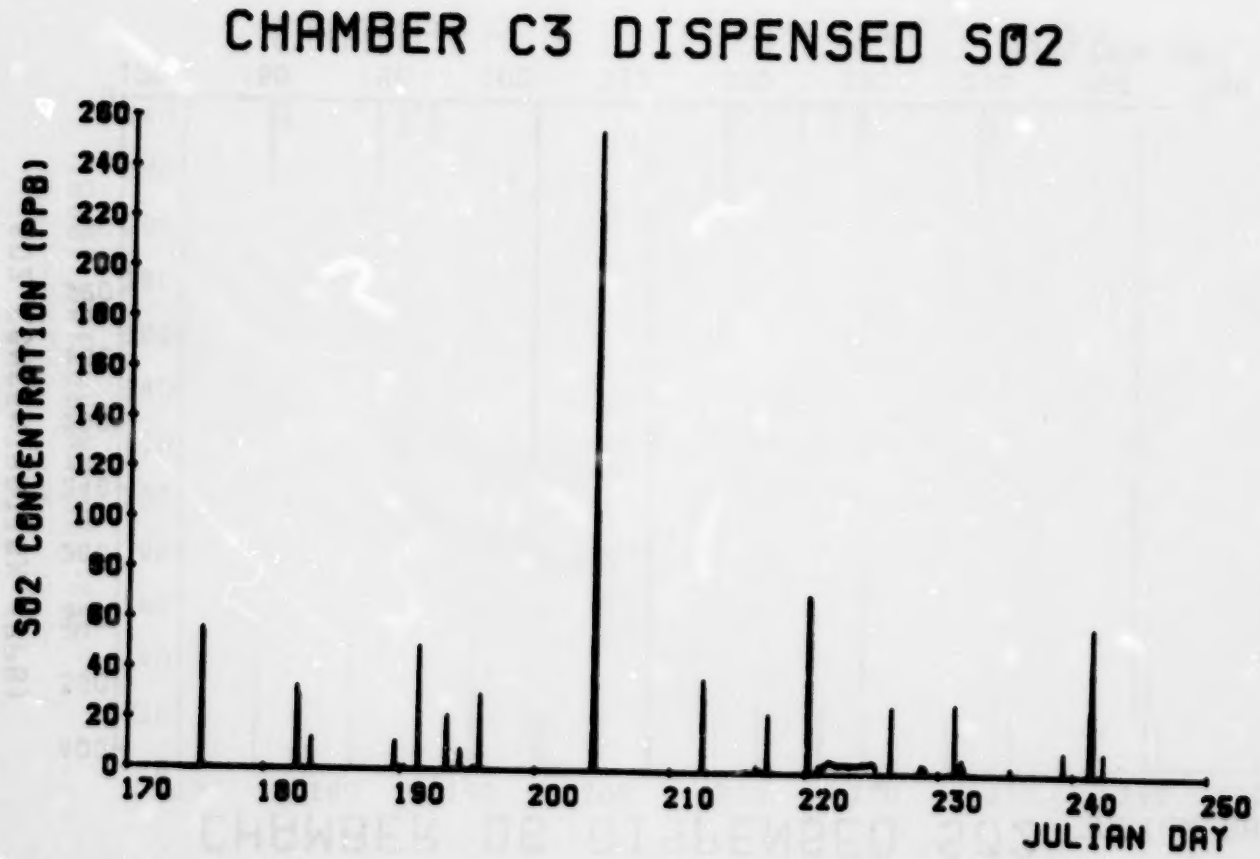


Figure 4. Chamber C3-dispensed $SO_2$.

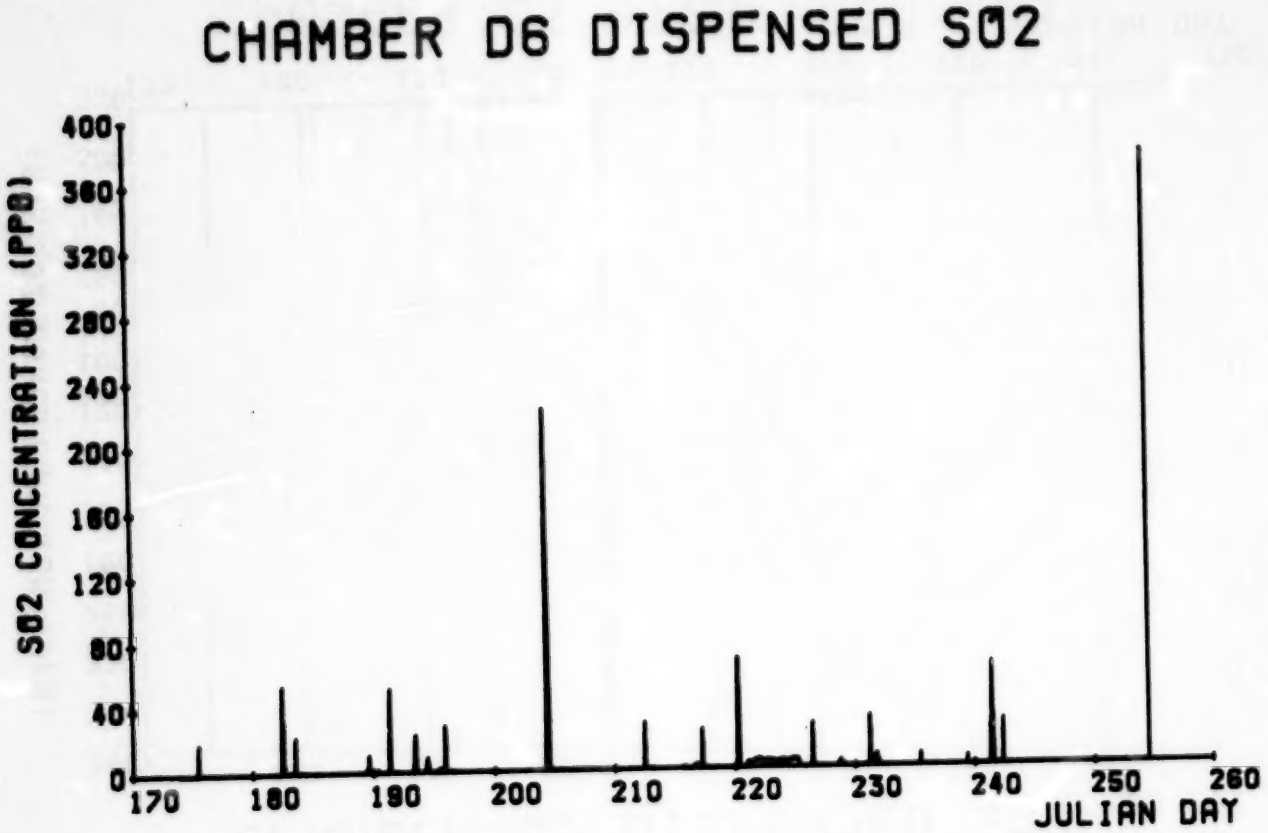


Figure 5. Chamber D6-dispensed $SO_2$.

Figure 6. Chamber E1-dispensed $SO_2$.

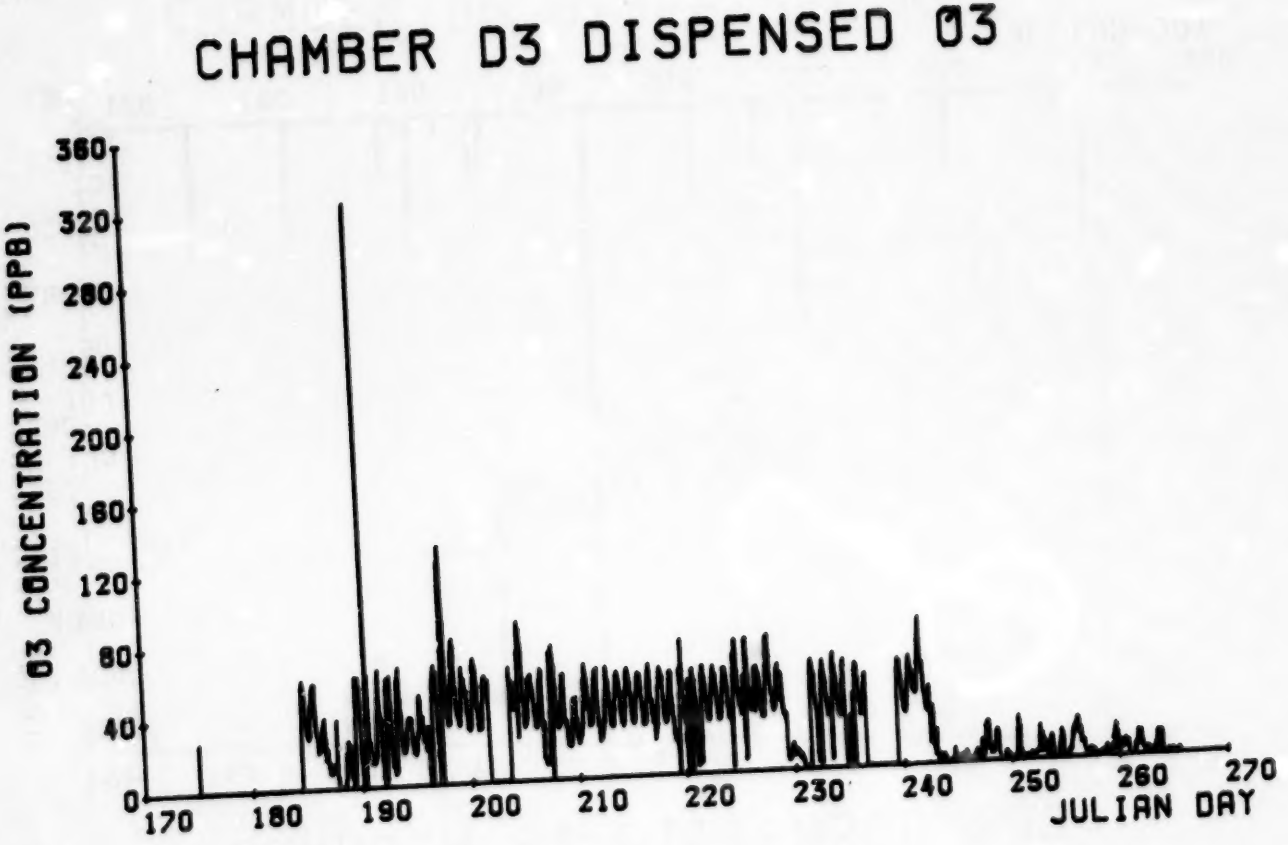


Figure 7. Chamber D3-dispensed $O_3$.

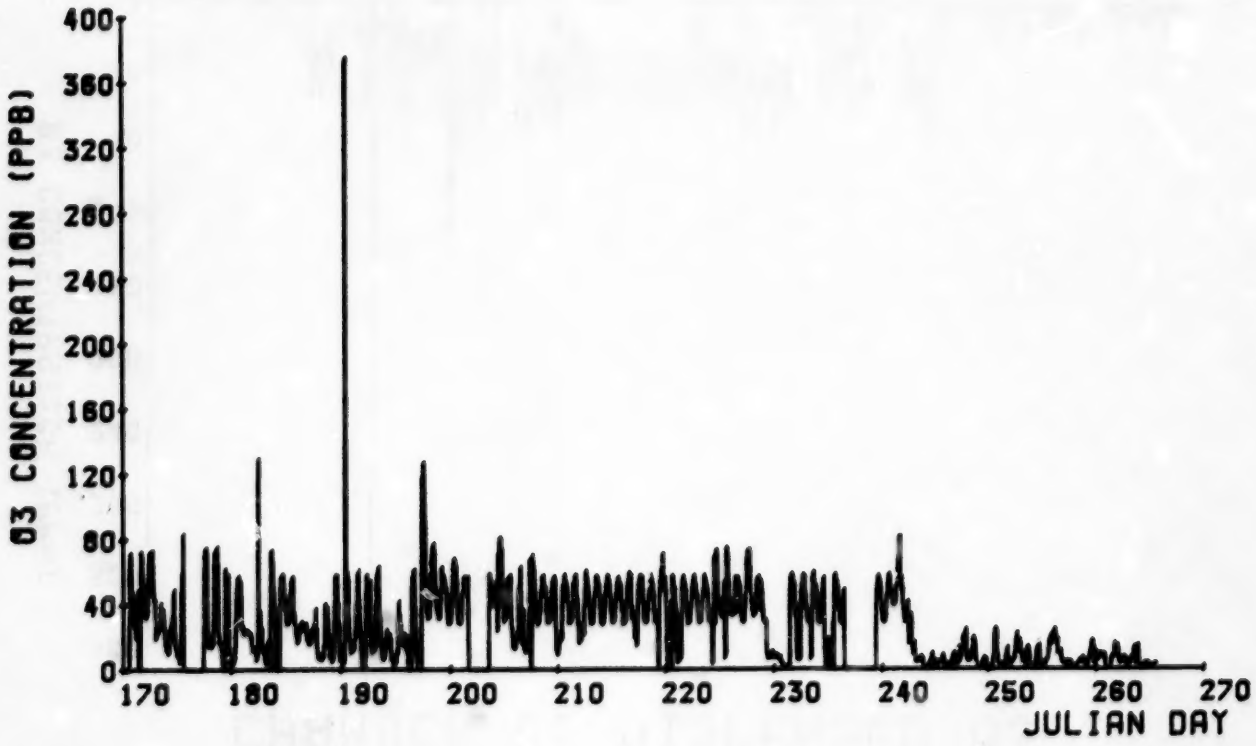


Figure 8. Chamber D4-dispensed $O_3$.

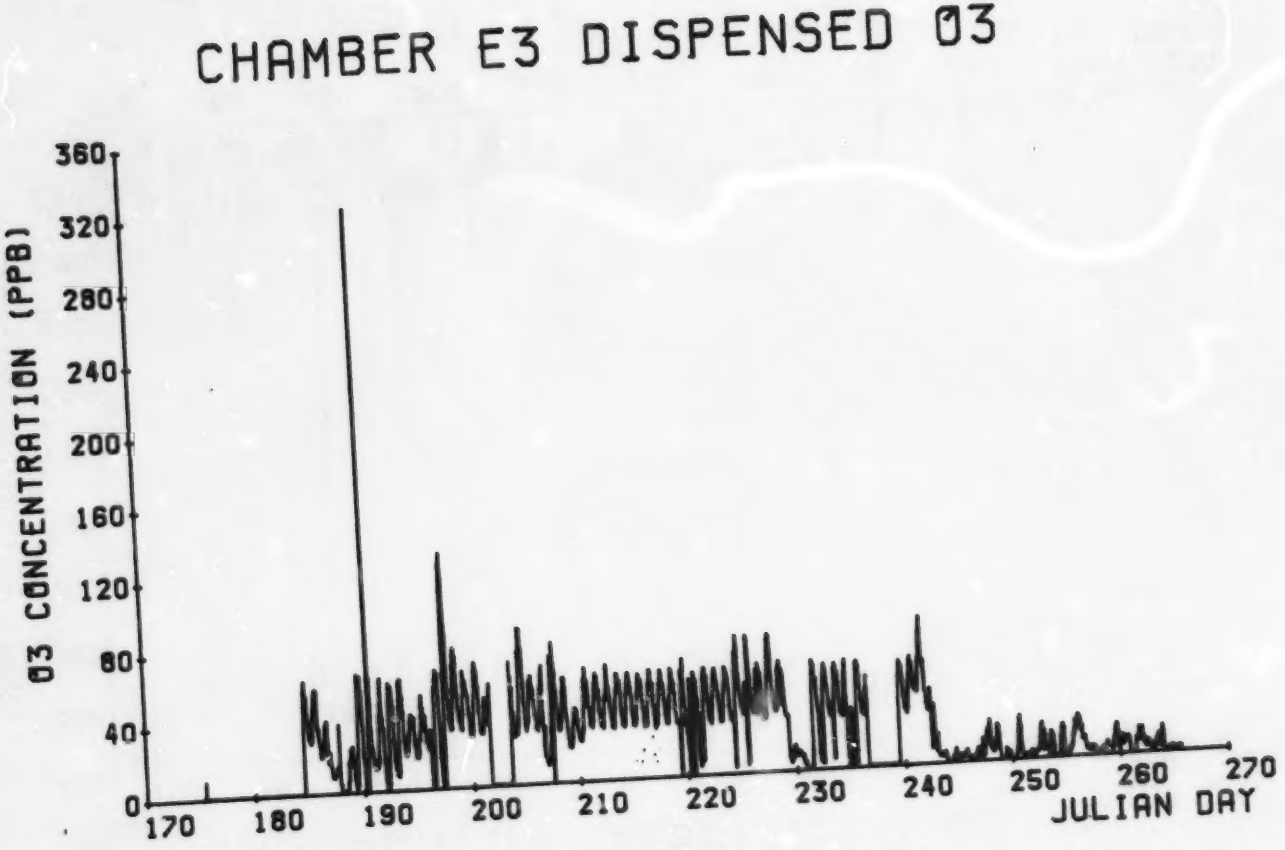


Figure 9. Chamber E3-dispensed $O_3$.